US010996636B2

(12) **United States Patent**
Morohoshi

(10) **Patent No.: US 10,996,636 B2**
(45) **Date of Patent: May 4, 2021**

(54) **COMMUNICATION DEVICE, ELECTRONIC TIMEPIECE, COMMUNICATION METHOD, AND RECORDING MEDIUM**

(71) Applicant: **CASIO COMPUTER CO., LTD.**, Tokyo (JP)

(72) Inventor: **Hiroshi Morohoshi**, Tokorozawa (JP)

(73) Assignee: **CASIO COMPUTER CO., LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 434 days.

(21) Appl. No.: **15/900,445**

(22) Filed: **Feb. 20, 2018**

(65) **Prior Publication Data**

US 2018/0267484 A1 Sep. 20, 2018

(30) **Foreign Application Priority Data**

Mar. 16, 2017 (JP) JP2017-051447

(51) **Int. Cl.**
G04R 20/26 (2013.01)

(52) **U.S. Cl.**
CPC ***G04R 20/26*** (2013.01)

(58) **Field of Classification Search**
CPC G04R 20/02; G04R 20/08; G04R 20/14; G04R 20/20; G04R 20/26
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,234,958 A * 11/1980 Pipes G04R 40/00 368/47
5,528,560 A * 6/1996 Ogiyama G04G 3/022 368/47
2003/0198140 A1 10/2003 Shimizu et al.
2004/0047244 A1* 3/2004 Iino G04R 20/08 368/276
2004/0190379 A1* 9/2004 Akiba G04R 20/26 368/47
2007/0230285 A1* 10/2007 Nakagawa G04R 20/02 368/47

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2002139586 A 5/2002
JP 2004003929 A 1/2004

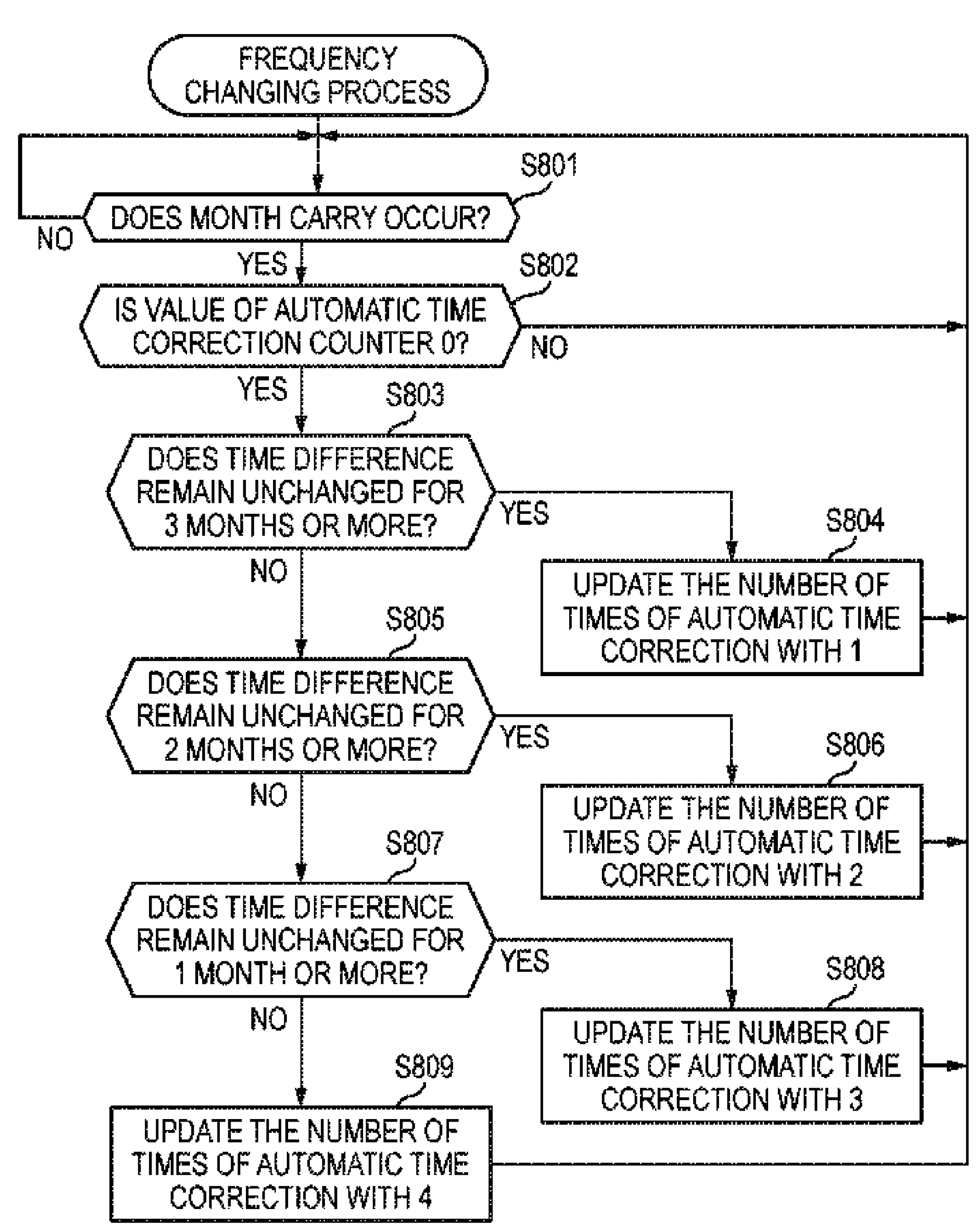
(Continued)

Primary Examiner — Daniel P Wicklund
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

The communication device includes a receiver, a counter, an operation member and a processor. The receiver receives an external time from an external device. The counter clocks time. The operation member receives a time correction operation to correct the time clocked by the counter. The processor corrects the time clocked by the counter to the received external time. The processor sets a frequency at which the time correction process is performed after the operation member receives the time correction operation, higher than a frequency at which the time correction process is performed before the operation member receives the time correction operation, until a predetermined time elapses. In the time correction process, when the difference between the time clocked by the counter and the external time received by the receiver is within a predetermined range, the processor corrects the time clocked by the counter to the external time.

9 Claims, 21 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0135677	A1*	5/2009	Veillette	G04R 40/06 368/47
2014/0241133	A1*	8/2014	Baba	G04R 20/04 368/47
2017/0277140	A1*	9/2017	Akiyama	G04R 20/02
2018/0372880	A1*	12/2018	Matsue	H03K 3/0307

FOREIGN PATENT DOCUMENTS

JP	2005351674	A	12/2005
JP	2006322812	A	11/2006
JP	2009118403	A	5/2009
JP	2011174870	A	9/2011
JP	2017026576	A	2/2017

* cited by examiner

FIG. 1

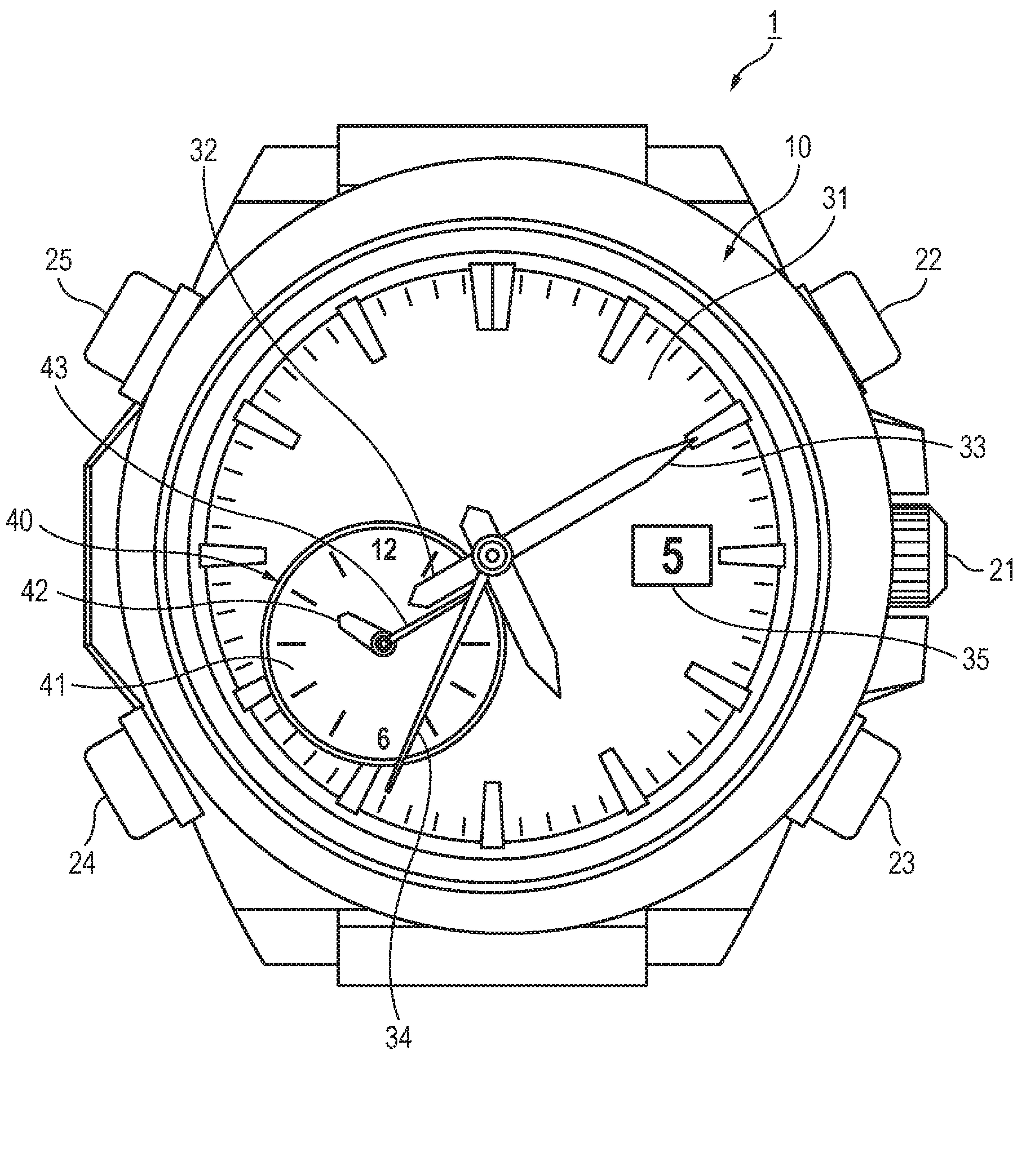


FIG. 2

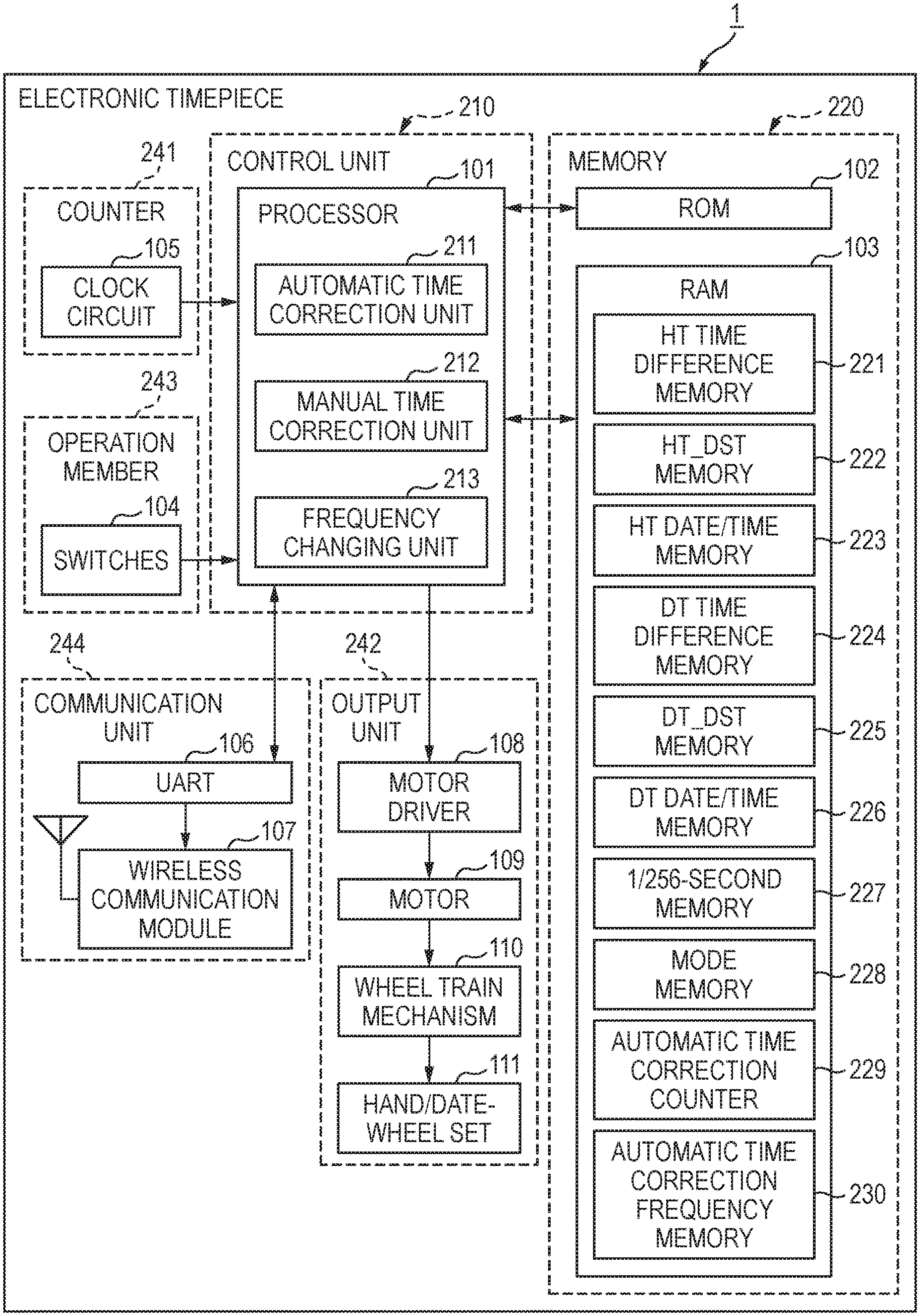

1
ELECTRONIC TIMEPIECE
210
CONTROL UNIT
220
MEMORY
241
COUNTER
105
CLOCK CIRCUIT
101
PROCESSOR
211
AUTOMATIC TIME CORRECTION UNIT
212
MANUAL TIME CORRECTION UNIT
213
FREQUENCY CHANGING UNIT
102
ROM
103
RAM
HT TIME DIFFERENCE MEMORY
221
HT_DST MEMORY
222
HT DATE/TIME MEMORY
223
DT TIME DIFFERENCE MEMORY
224
DT_DST MEMORY
225
DT DATE/TIME MEMORY
226
1/256-SECOND MEMORY
227
MODE MEMORY
228
AUTOMATIC TIME CORRECTION COUNTER
229
AUTOMATIC TIME CORRECTION FREQUENCY MEMORY
230
243
OPERATION MEMBER
104
SWITCHES
244
COMMUNICATION UNIT
106
UART
107
WIRELESS COMMUNICATION MODULE
242
OUTPUT UNIT
108
MOTOR DRIVER
109
MOTOR
110
WHEEL TRAIN MECHANISM
111
HAND/DATE-WHEEL SET

FIG. 3

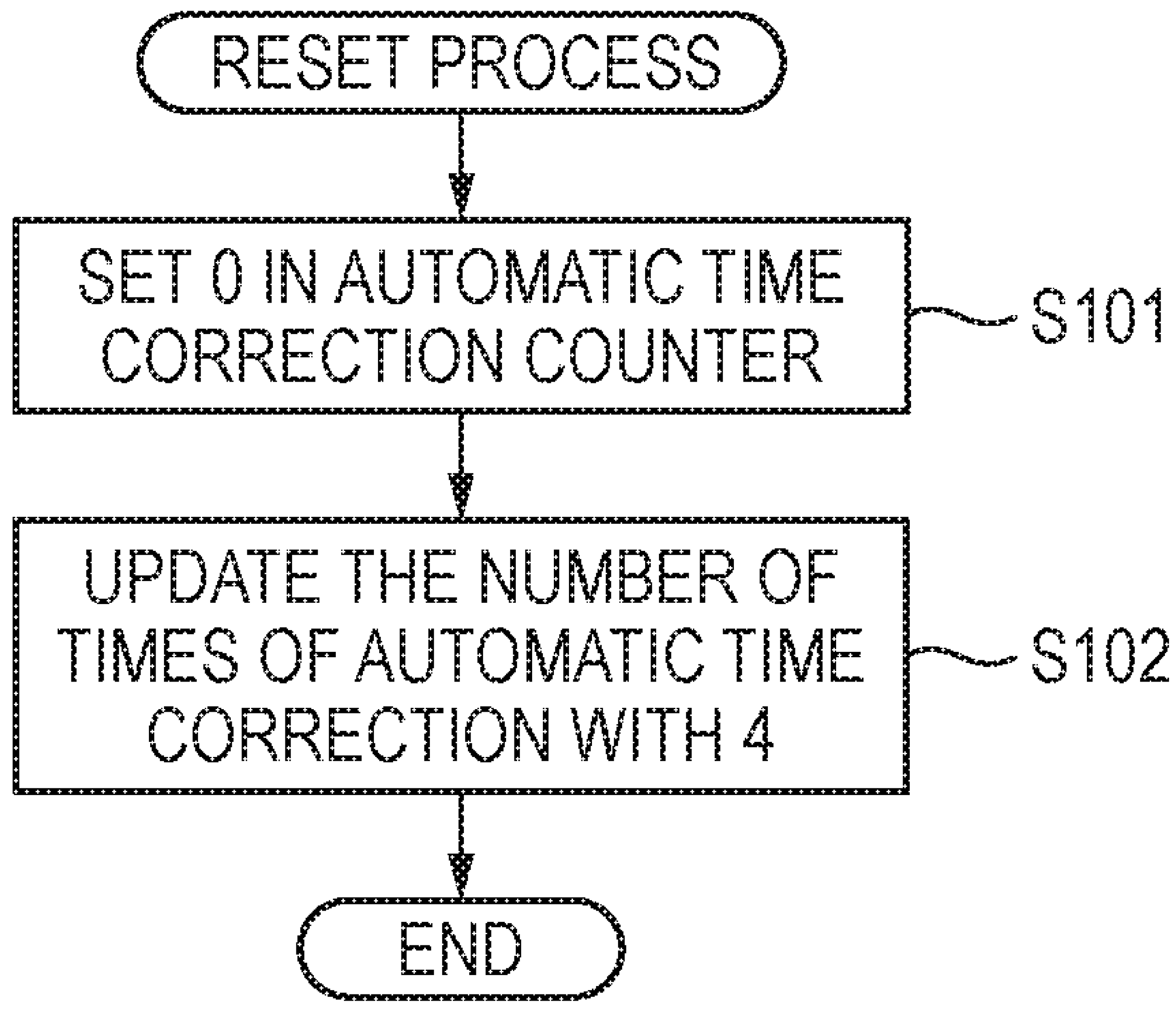

RESET PROCESS
SET 0 IN AUTOMATIC TIME CORRECTION COUNTER
S101
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4
S102
END

FIG. 4

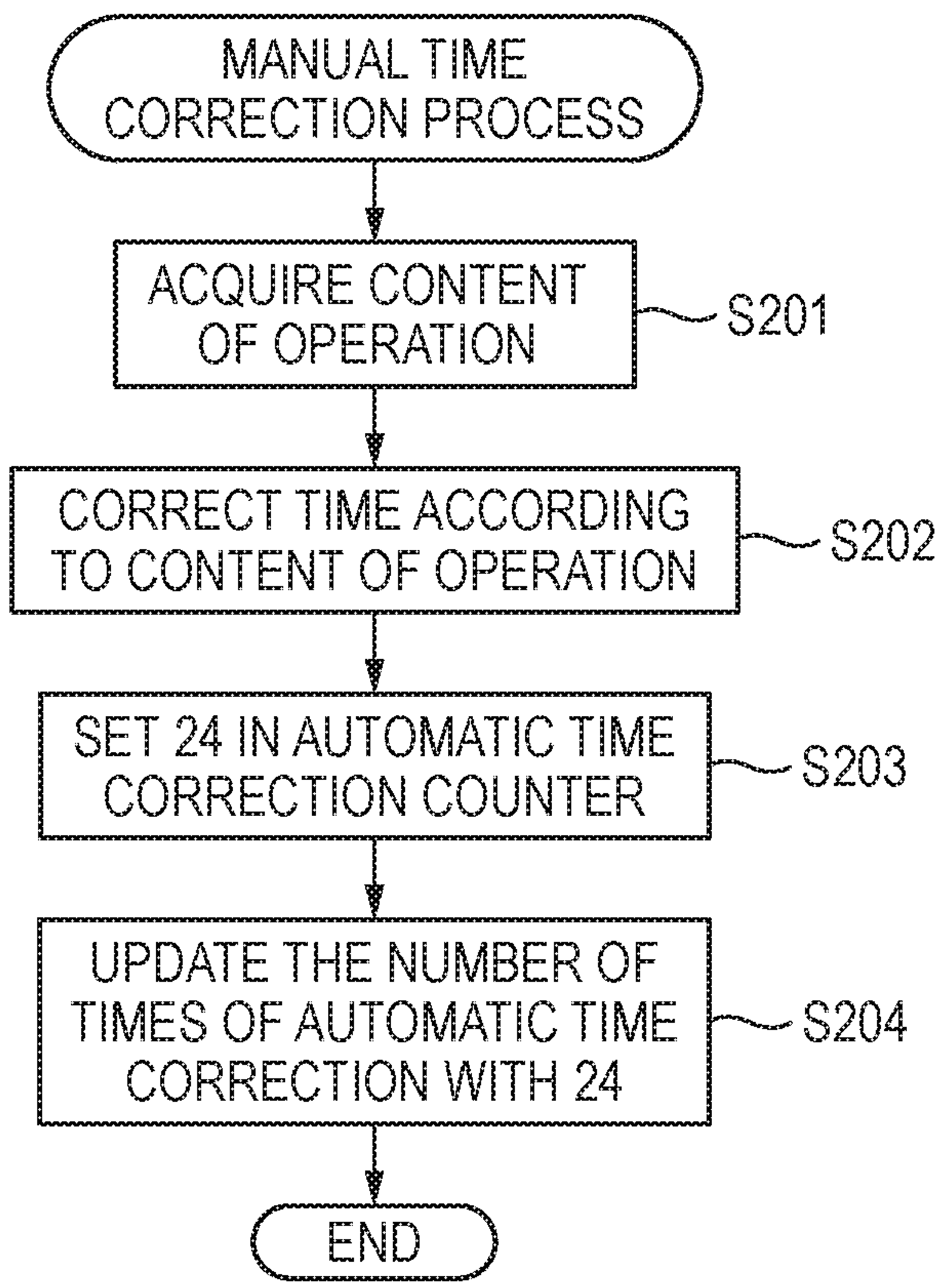

MANUAL TIME CORRECTION PROCESS
ACQUIRE CONTENT OF OPERATION
S201
CORRECT TIME ACCORDING TO CONTENT OF OPERATION
S202
SET 24 IN AUTOMATIC TIME CORRECTION COUNTER
S203
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 24
S204
END

FIG. 5

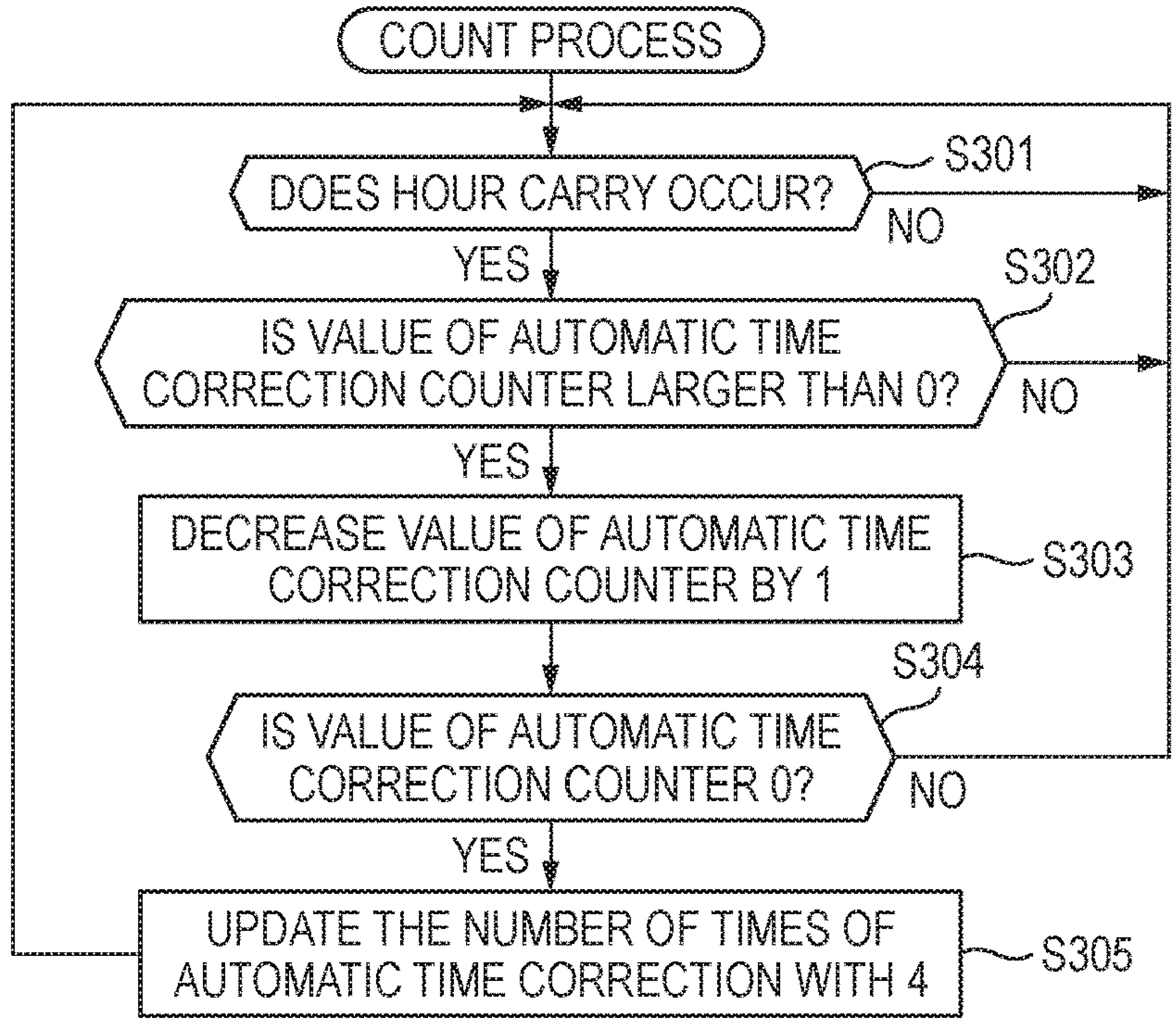

COUNT PROCESS
DOES HOUR CARRY OCCUR?
S301
NO
YES
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER LARGER THAN 0?
S302
NO
YES
DECREASE VALUE OF AUTOMATIC TIME CORRECTION COUNTER BY 1
S303
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
S304
NO
YES
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4
S305

FIG. 6

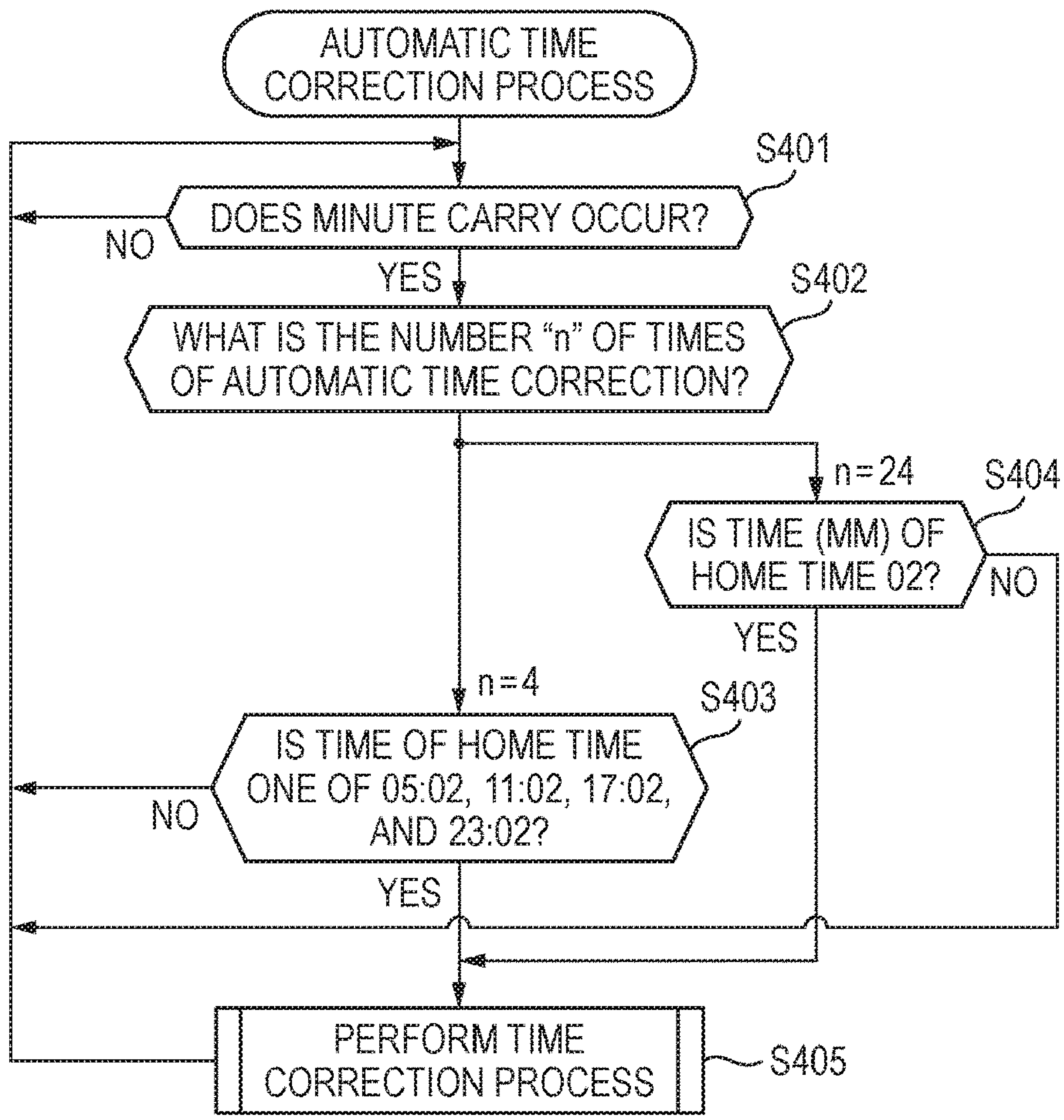
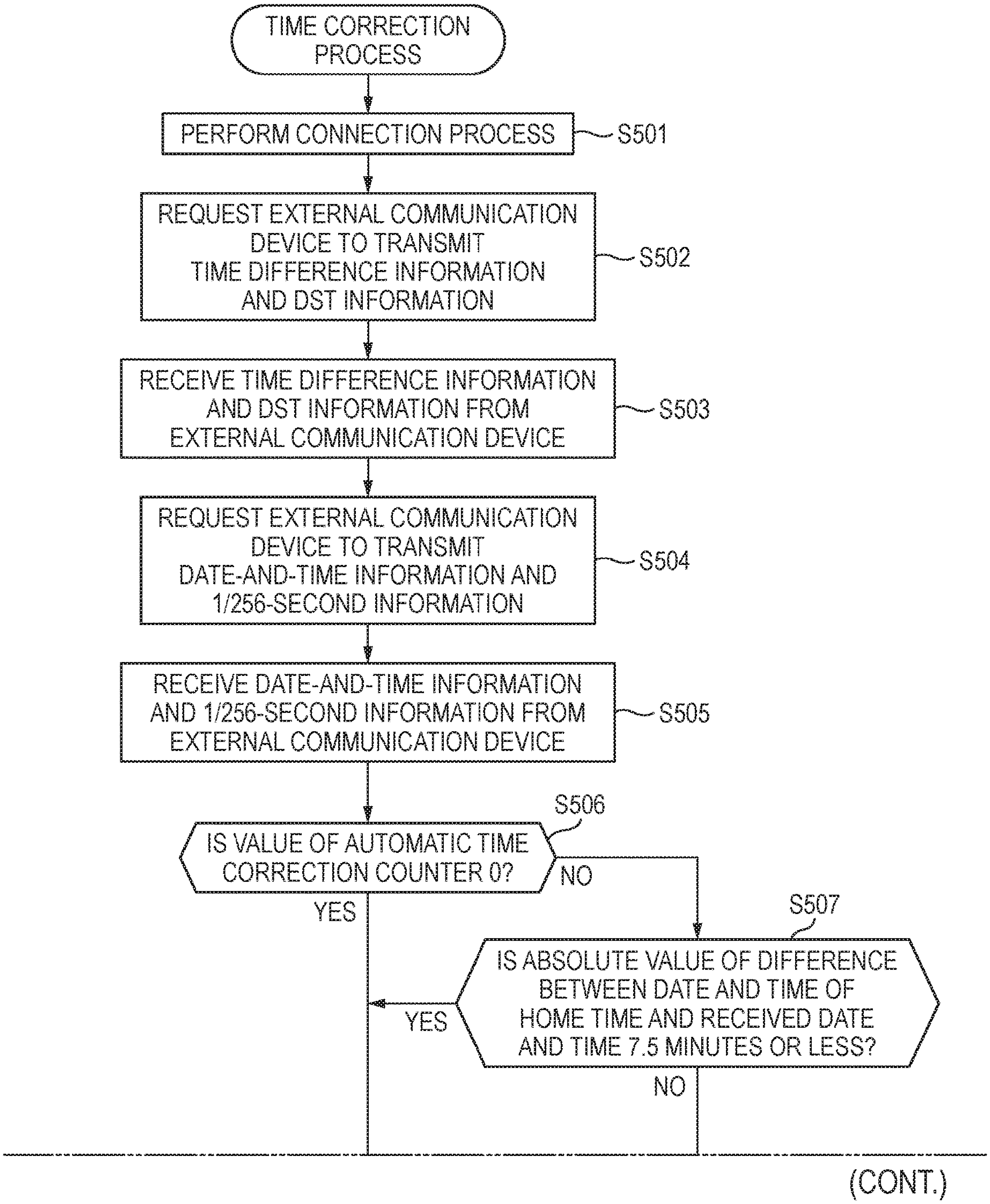

AUTOMATIC TIME CORRECTION PROCESS
DOES MINUTE CARRY OCCUR?
S401
NO
YES
WHAT IS THE NUMBER "n" OF TIMES OF AUTOMATIC TIME CORRECTION?
S402
n=24
IS TIME (MM) OF HOME TIME 02?
S404
NO
YES
n=4
IS TIME OF HOME TIME ONE OF 05:02, 11:02, 17:02, AND 23:02?
S403
NO
YES
PERFORM TIME CORRECTION PROCESS
S405

FIG. 7


TIME CORRECTION PROCESS
PERFORM CONNECTION PROCESS
S501
REQUEST EXTERNAL COMMUNICATION DEVICE TO TRANSMIT TIME DIFFERENCE INFORMATION AND DST INFORMATION
S502
RECEIVE TIME DIFFERENCE INFORMATION AND DST INFORMATION FROM EXTERNAL COMMUNICATION DEVICE
S503
REQUEST EXTERNAL COMMUNICATION DEVICE TO TRANSMIT DATE-AND-TIME INFORMATION AND 1/256-SECOND INFORMATION
S504
RECEIVE DATE-AND-TIME INFORMATION AND 1/256-SECOND INFORMATION FROM EXTERNAL COMMUNICATION DEVICE
S505
S506
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S507
IS ABSOLUTE VALUE OF DIFFERENCE BETWEEN DATE AND TIME OF HOME TIME AND RECEIVED DATE AND TIME 7.5 MINUTES OR LESS?
YES
NO
(CONT.)

(FIG. 7 CONTINUED)

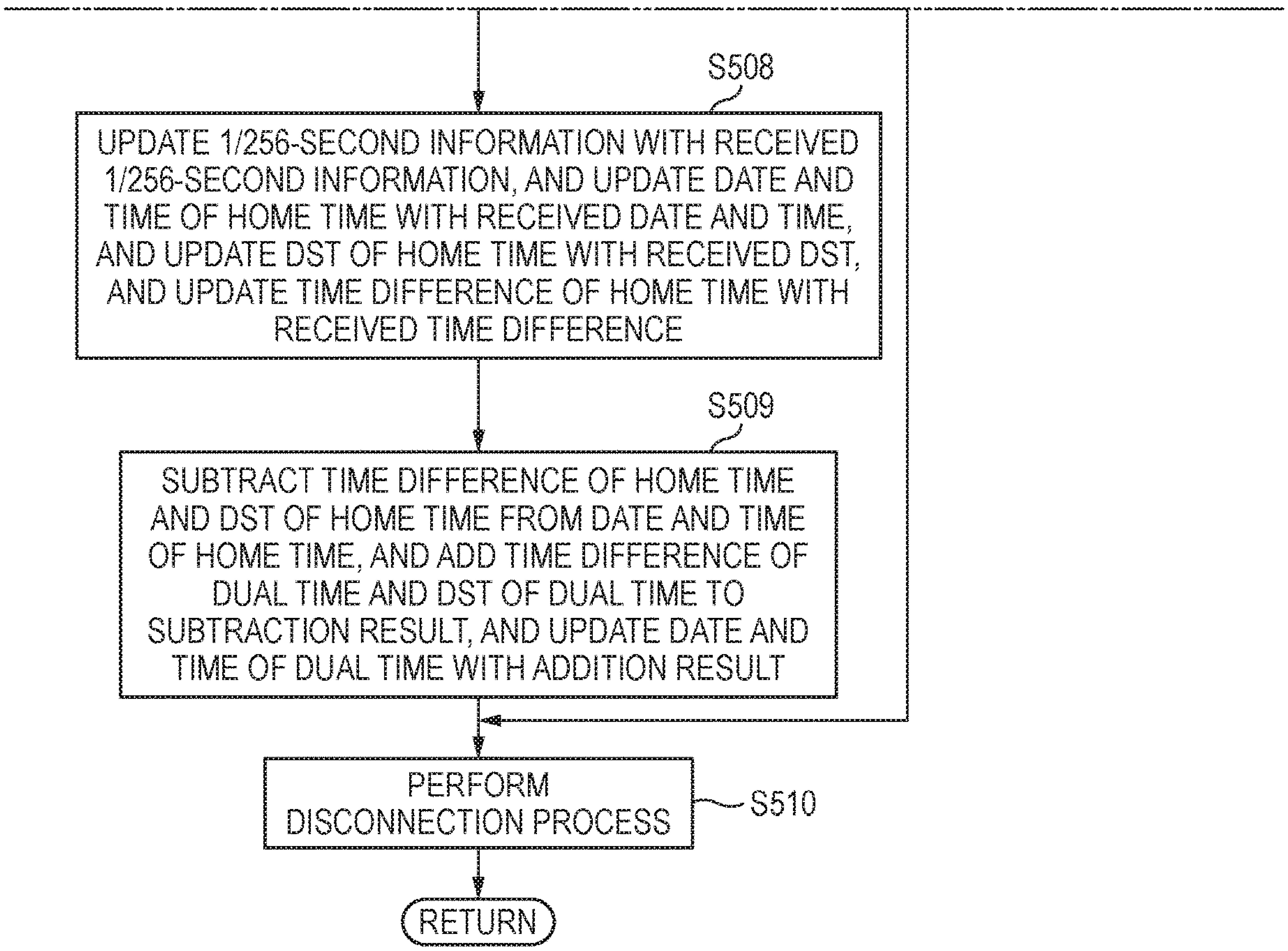


FIG. 8

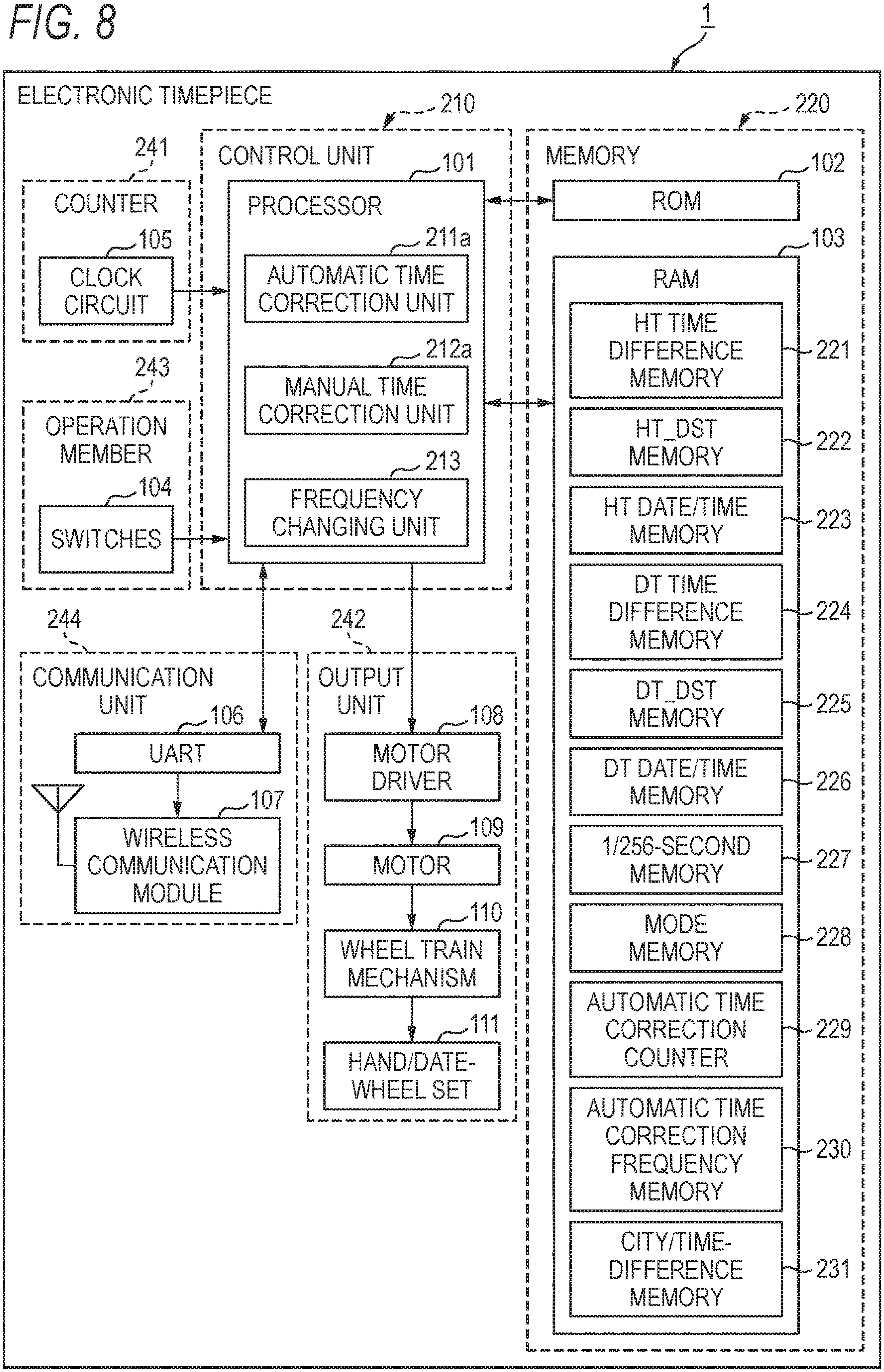
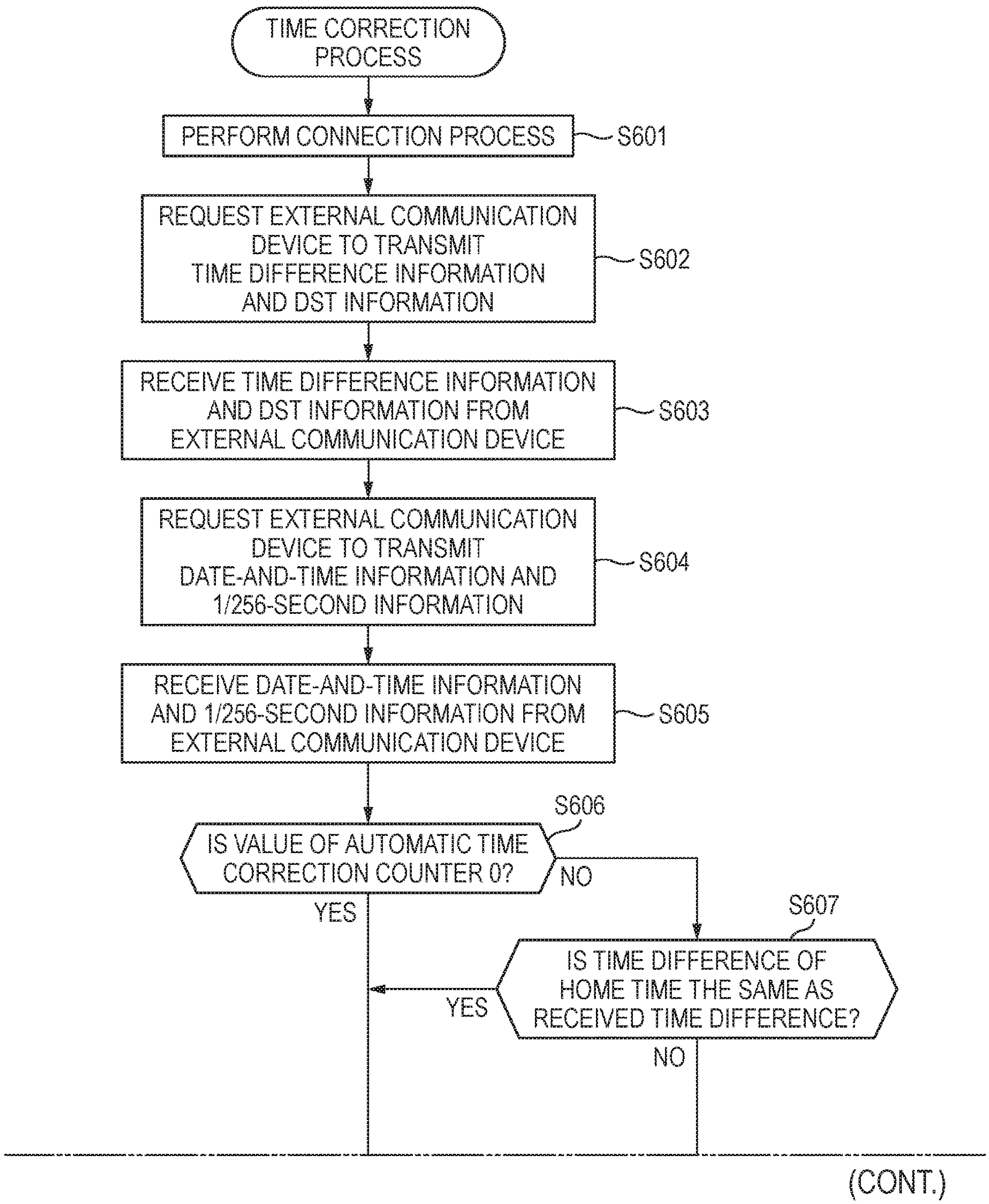

1
ELECTRONIC TIMEPIECE
210
CONTROL UNIT
220
MEMORY
241
COUNTER
105
CLOCK CIRCUIT
101
PROCESSOR
211a
AUTOMATIC TIME CORRECTION UNIT
212a
MANUAL TIME CORRECTION UNIT
213
FREQUENCY CHANGING UNIT
243
OPERATION MEMBER
104
SWITCHES
102
ROM
103
RAM
HT TIME DIFFERENCE MEMORY
221
HT_DST MEMORY
222
HT DATE/TIME MEMORY
223
DT TIME DIFFERENCE MEMORY
224
DT_DST MEMORY
225
DT DATE/TIME MEMORY
226
1/256-SECOND MEMORY
227
MODE MEMORY
228
AUTOMATIC TIME CORRECTION COUNTER
229
AUTOMATIC TIME CORRECTION FREQUENCY MEMORY
230
CITY/TIME-DIFFERENCE MEMORY
231
244
COMMUNICATION UNIT
106
UART
107
WIRELESS COMMUNICATION MODULE
242
OUTPUT UNIT
108
MOTOR DRIVER
109
MOTOR
110
WHEEL TRAIN MECHANISM
111
HAND/DATE-WHEEL SET

FIG. 9

231

CITY CODE	TIME DIFFERENCE
UTC	0
LONDON (LON)	0
PARIS (PAR)	+1
ATHENS (ATH)	+2
TOKYO (TYO)	+9
⋮	⋮

FIG. 10


TIME CORRECTION PROCESS
PERFORM CONNECTION PROCESS
S601
REQUEST EXTERNAL COMMUNICATION DEVICE TO TRANSMIT TIME DIFFERENCE INFORMATION AND DST INFORMATION
S602
RECEIVE TIME DIFFERENCE INFORMATION AND DST INFORMATION FROM EXTERNAL COMMUNICATION DEVICE
S603
REQUEST EXTERNAL COMMUNICATION DEVICE TO TRANSMIT DATE-AND-TIME INFORMATION AND 1/256-SECOND INFORMATION
S604
RECEIVE DATE-AND-TIME INFORMATION AND 1/256-SECOND INFORMATION FROM EXTERNAL COMMUNICATION DEVICE
S605
S606
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S607
IS TIME DIFFERENCE OF HOME TIME THE SAME AS RECEIVED TIME DIFFERENCE?
YES
NO
(CONT.)

(FIG. 10 CONTINUED)

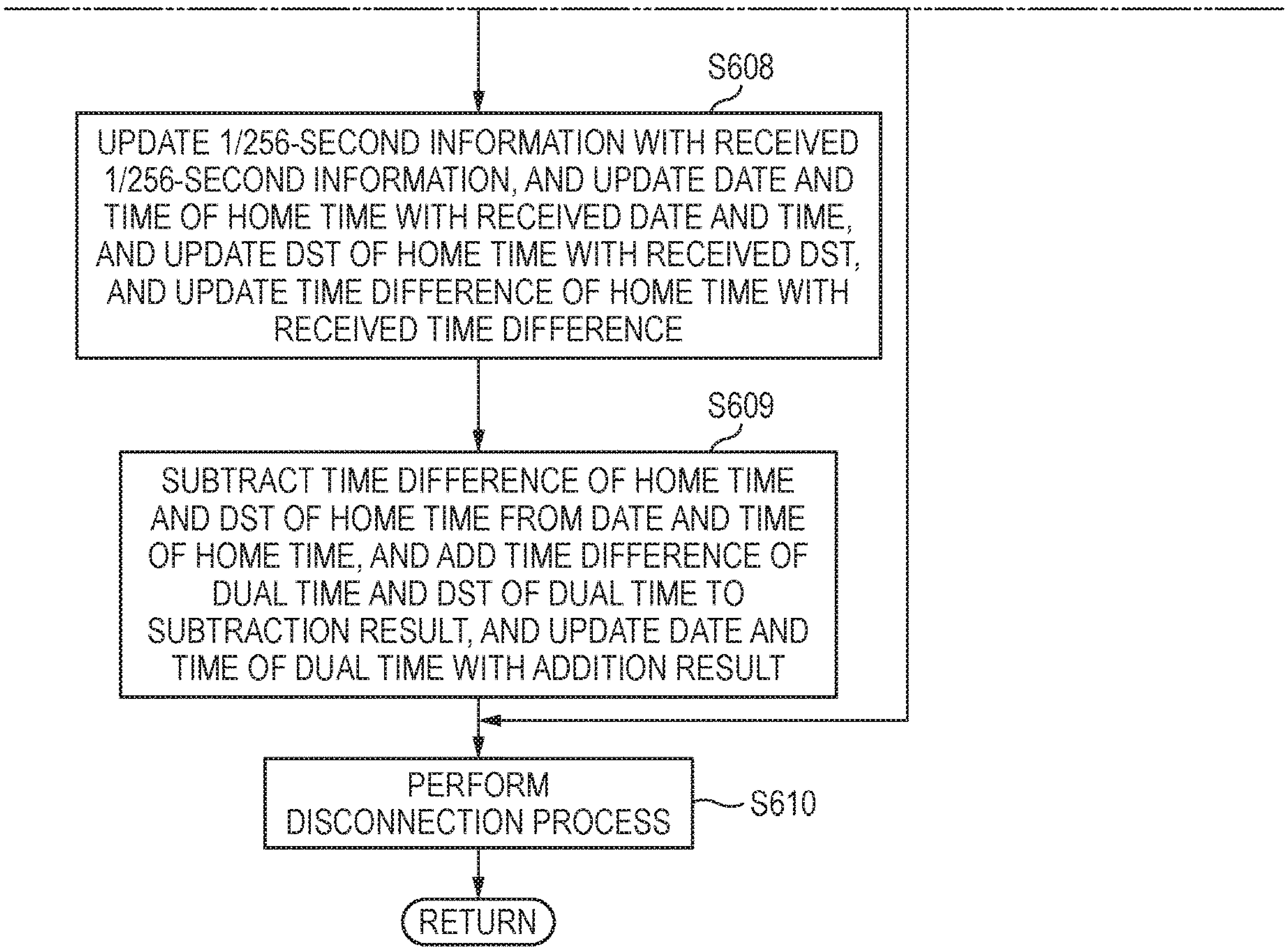


FIG. 11

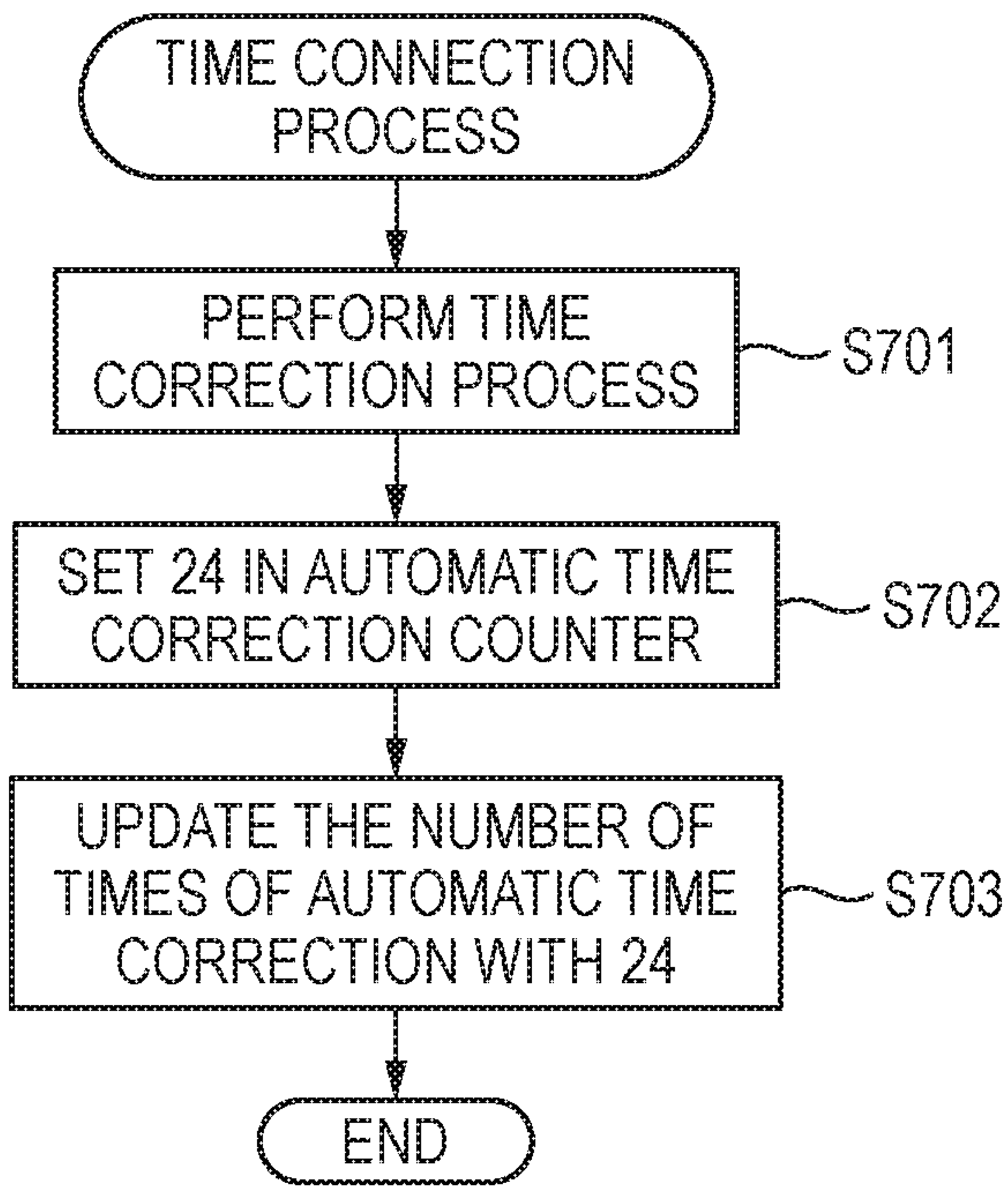
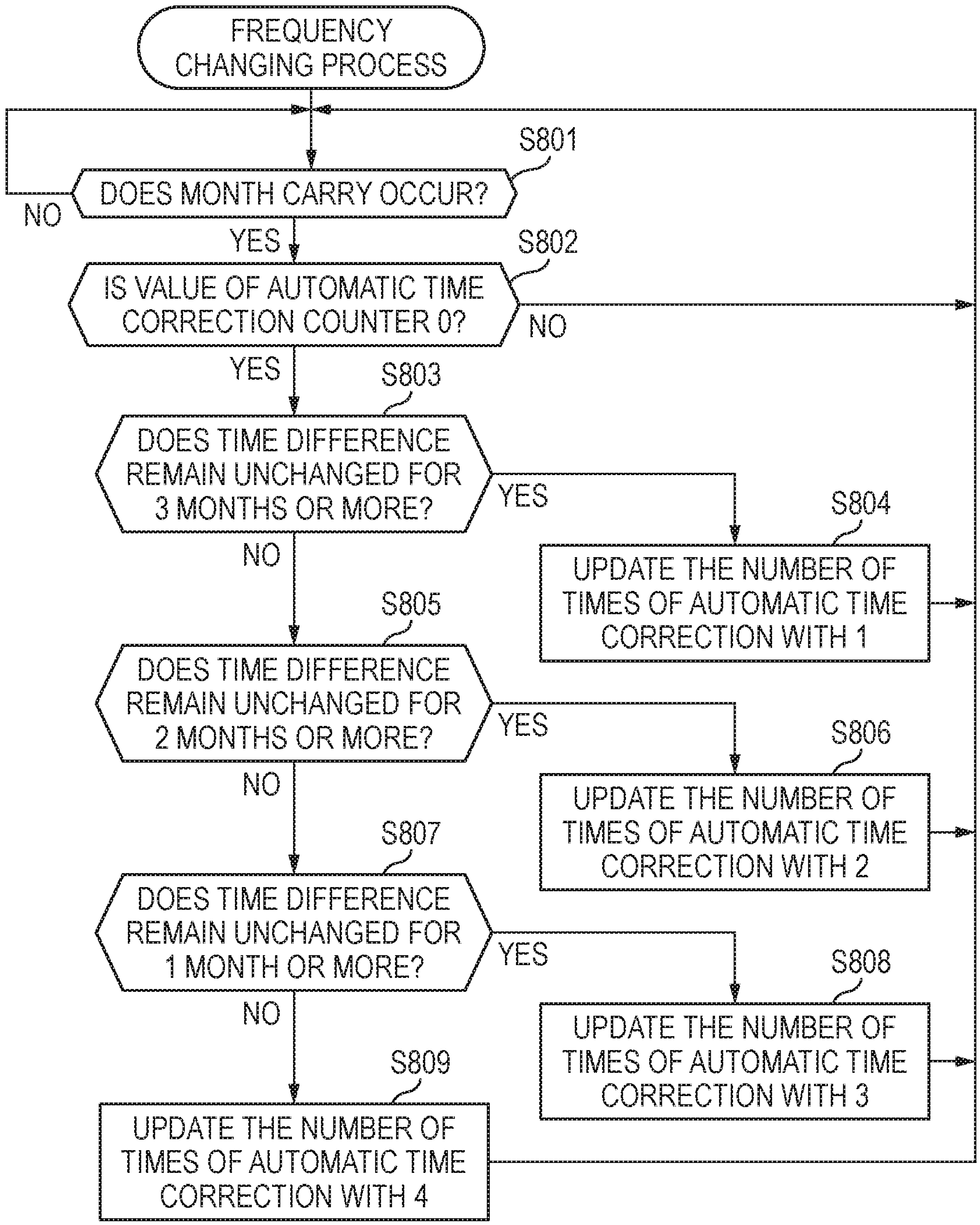

TIME CONNECTION PROCESS
PERFORM TIME CORRECTION PROCESS
S701
SET 24 IN AUTOMATIC TIME CORRECTION COUNTER
S702
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 24
S703
END

FIG. 12


FREQUENCY CHANGING PROCESS
S801
DOES MONTH CARRY OCCUR?
NO
YES
S802
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S803
DOES TIME DIFFERENCE REMAIN UNCHANGED FOR 3 MONTHS OR MORE?
YES
S804
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 1
NO
S805
DOES TIME DIFFERENCE REMAIN UNCHANGED FOR 2 MONTHS OR MORE?
YES
S806
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 2
NO
S807
DOES TIME DIFFERENCE REMAIN UNCHANGED FOR 1 MONTH OR MORE?
YES
S808
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 3
NO
S809
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4

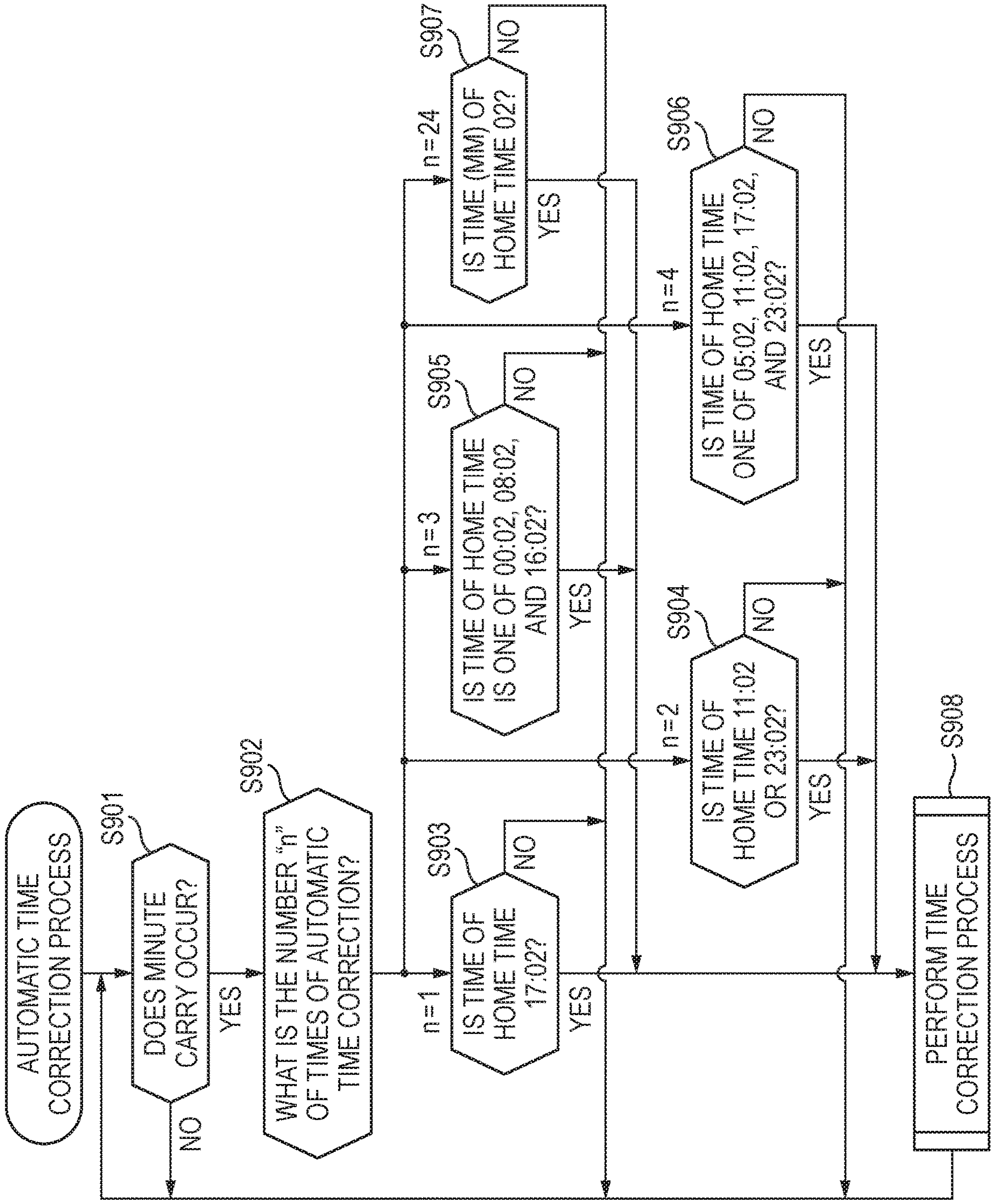

AUTOMATIC TIME CORRECTION PROCESS
S901
DOES MINUTE CARRY OCCUR?
YES
NO
S902
WHAT IS THE NUMBER "n" OF TIMES OF AUTOMATIC TIME CORRECTION?
n=1
S903
IS TIME OF HOME TIME 17:02?
YES
NO
n=2
S904
IS TIME OF HOME TIME 11:02 OR 23:02?
YES
NO
n=3
S905
IS TIME OF HOME TIME IS ONE OF 00:02, 08:02, AND 16:02?
YES
NO
n=4
S906
IS TIME OF HOME TIME ONE OF 05:02, 11:02, 17:02, AND 23:02?
YES
NO
n=24
S907
IS TIME (MM) OF HOME TIME 02?
YES
NO
S908
PERFORM TIME CORRECTION PROCESS

FIG. 13

FIG. 14

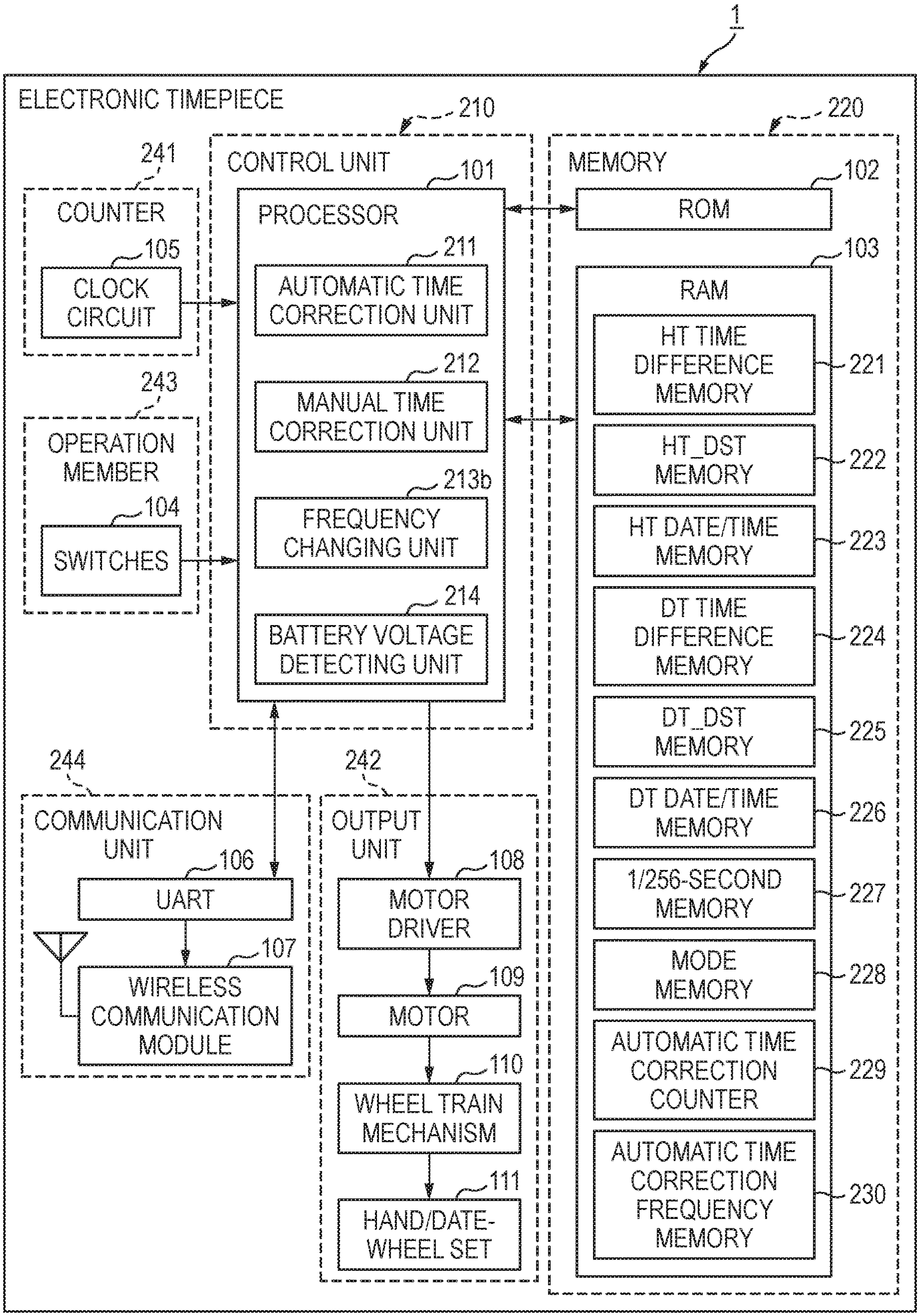

1
ELECTRONIC TIMEPIECE
210
220
CONTROL UNIT
MEMORY
241
COUNTER
101
PROCESSOR
102
ROM
105
CLOCK CIRCUIT
211
AUTOMATIC TIME CORRECTION UNIT
103
RAM
HT TIME DIFFERENCE MEMORY
221
212
MANUAL TIME CORRECTION UNIT
243
OPERATION MEMBER
HT_DST MEMORY
222
104
SWITCHES
213b
FREQUENCY CHANGING UNIT
HT DATE/TIME MEMORY
223
214
BATTERY VOLTAGE DETECTING UNIT
DT TIME DIFFERENCE MEMORY
224
DT_DST MEMORY
225
244
242
COMMUNICATION UNIT
OUTPUT UNIT
DT DATE/TIME MEMORY
226
106
UART
108
MOTOR DRIVER
1/256-SECOND MEMORY
227
107
WIRELESS COMMUNICATION MODULE
109
MOTOR
MODE MEMORY
228
110
WHEEL TRAIN MECHANISM
AUTOMATIC TIME CORRECTION COUNTER
229
111
HAND/DATE-WHEEL SET
AUTOMATIC TIME CORRECTION FREQUENCY MEMORY
230

FIG. 15

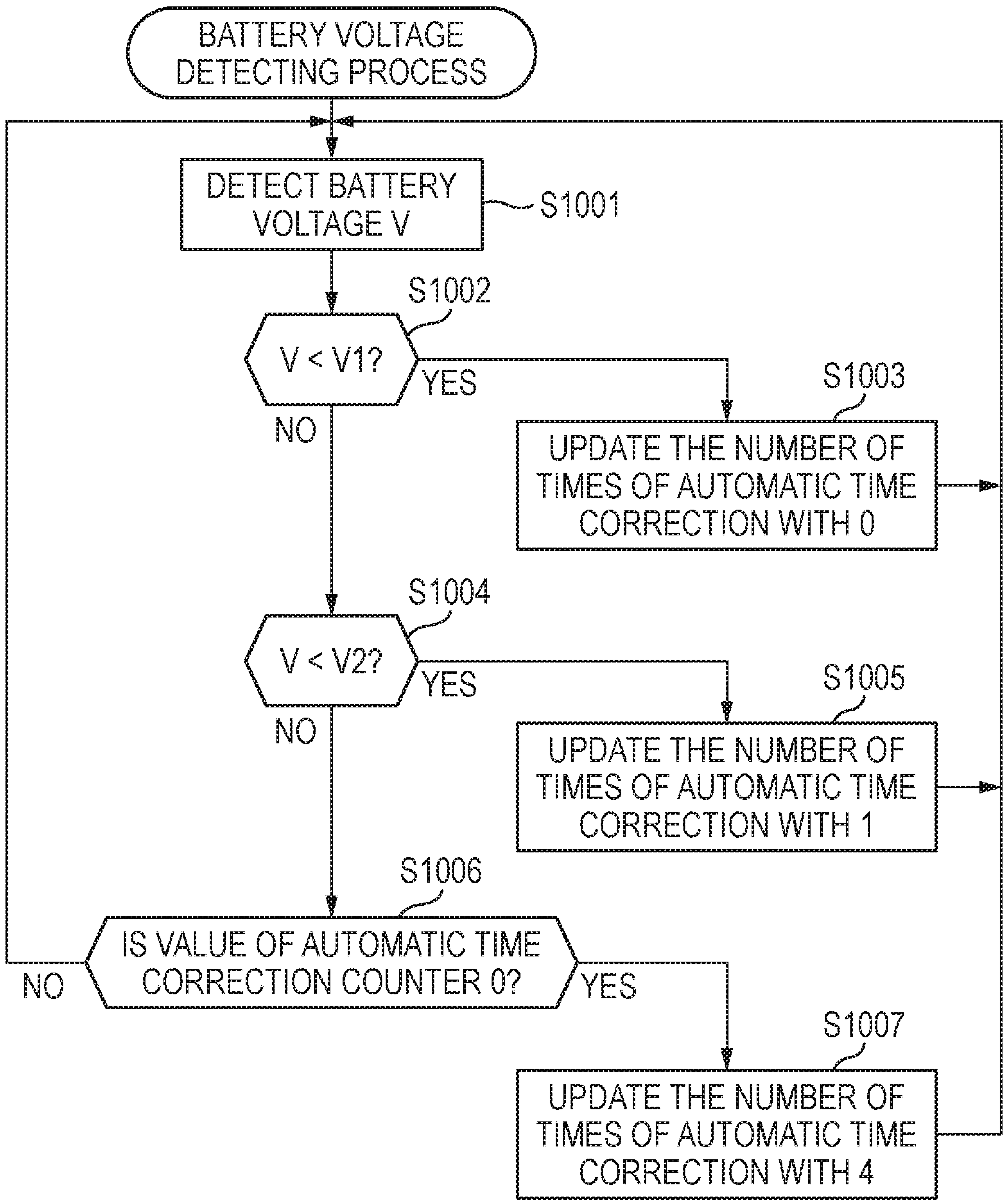

BATTERY VOLTAGE DETECTING PROCESS
DETECT BATTERY VOLTAGE V
S1001
S1002
V < V1?
YES
NO
S1003
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 0
S1004
V < V2?
YES
NO
S1005
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 1
S1006
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S1007
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4

FIG. 16

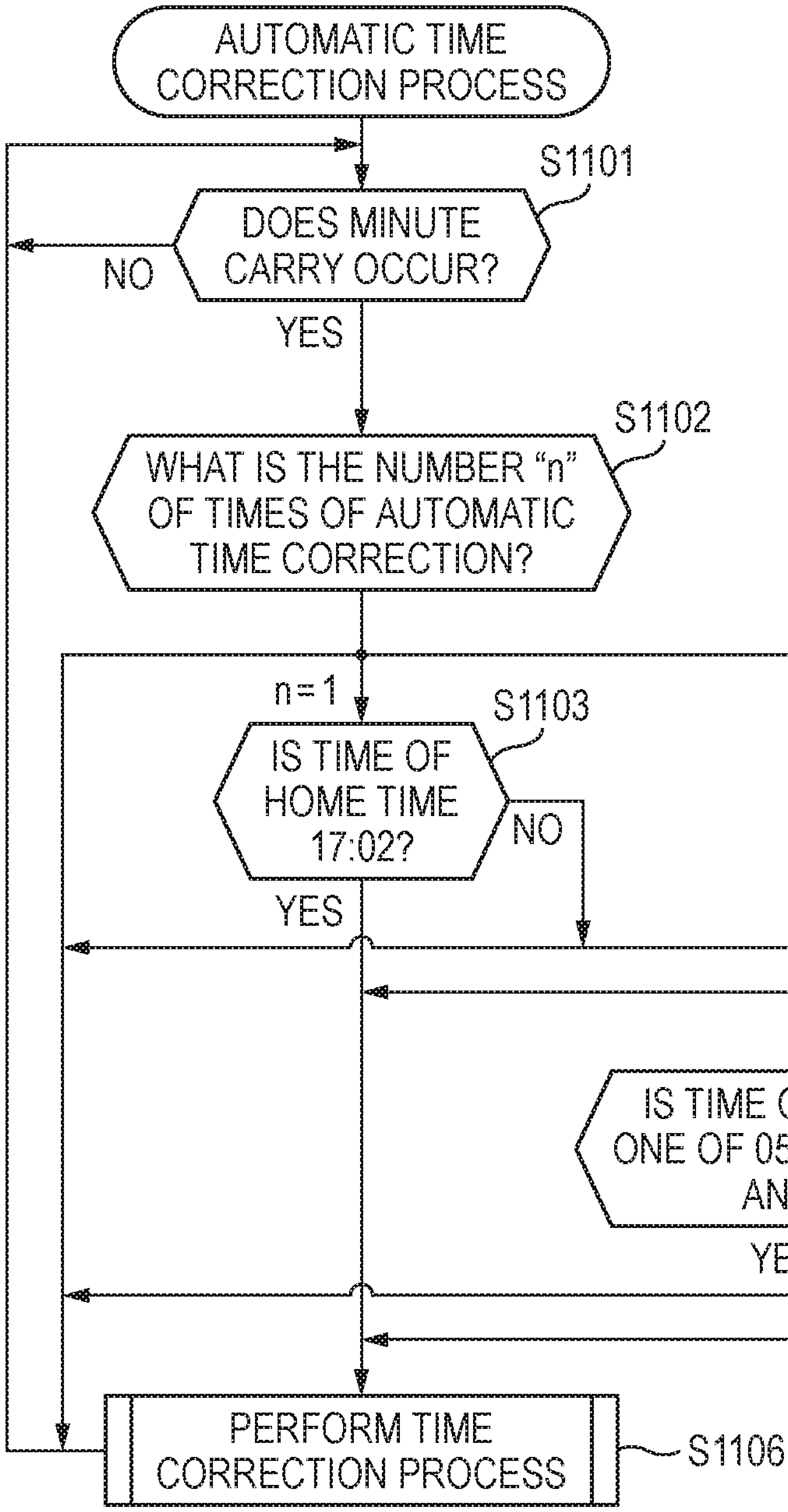

AUTOMATIC TIME CORRECTION PROCESS
S1101
DOES MINUTE CARRY OCCUR?
NO
YES
S1102
WHAT IS THE NUMBER "n" OF TIMES OF AUTOMATIC TIME CORRECTION?
n=1
S1103
IS TIME OF HOME TIME 17:02?
NO
YES
n=24
S1105
IS TIME (MM) OF HOME TIME 02?
NO
YES
n=4
S1104
IS TIME OF HOME TIME ONE OF 05:02, 11:02, 17:02, AND 23:02?
NO
YES
PERFORM TIME CORRECTION PROCESS
S1106

FIG. 17

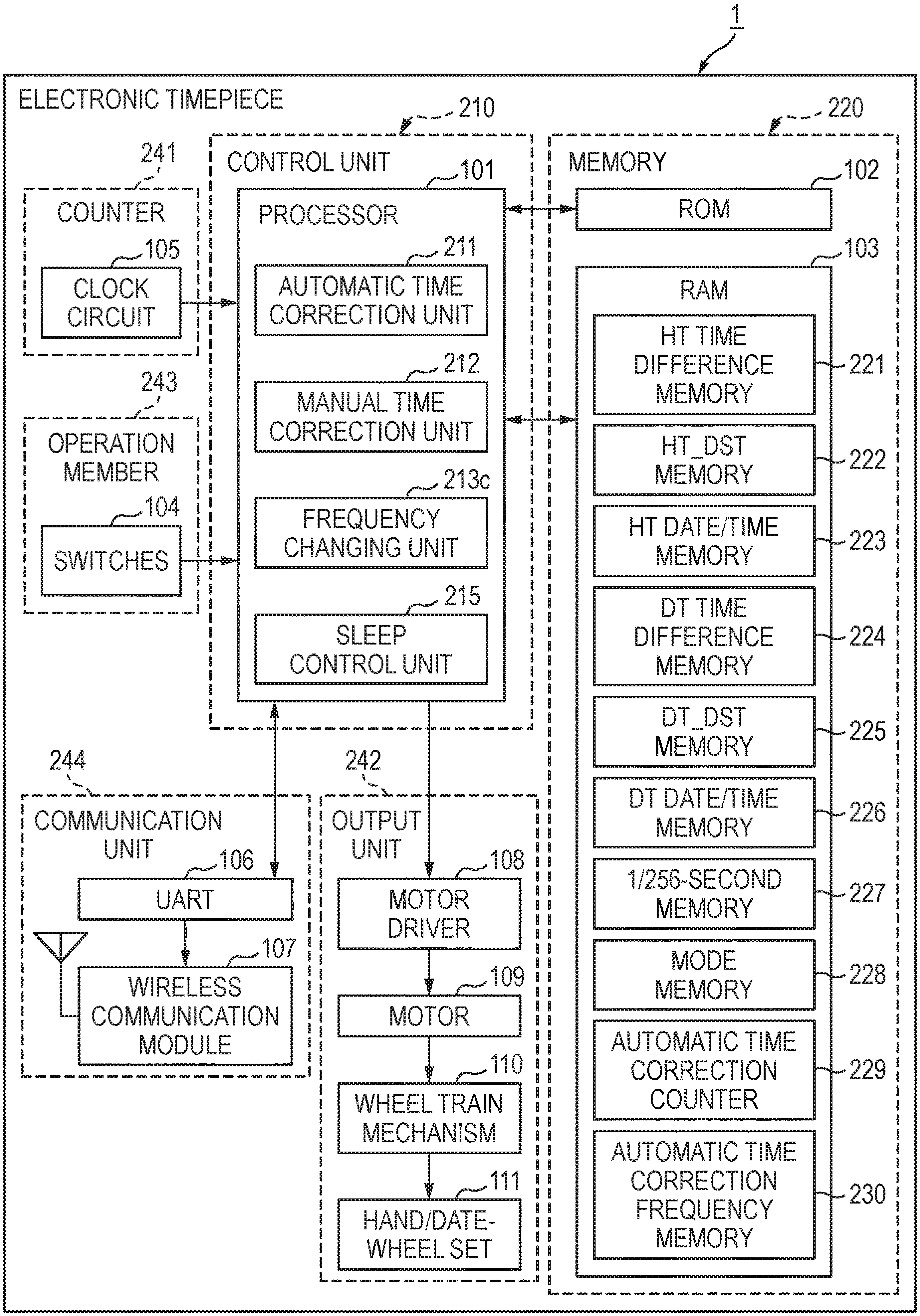

1
ELECTRONIC TIMEPIECE
210
CONTROL UNIT
220
MEMORY
241
COUNTER
105
CLOCK CIRCUIT
101
PROCESSOR
211
AUTOMATIC TIME CORRECTION UNIT
212
MANUAL TIME CORRECTION UNIT
213c
FREQUENCY CHANGING UNIT
215
SLEEP CONTROL UNIT
243
OPERATION MEMBER
104
SWITCHES
102
ROM
103
RAM
HT TIME DIFFERENCE MEMORY
221
HT_DST MEMORY
222
HT DATE/TIME MEMORY
223
DT TIME DIFFERENCE MEMORY
224
DT_DST MEMORY
225
DT DATE/TIME MEMORY
226
1/256-SECOND MEMORY
227
MODE MEMORY
228
AUTOMATIC TIME CORRECTION COUNTER
229
AUTOMATIC TIME CORRECTION FREQUENCY MEMORY
230
244
COMMUNICATION UNIT
106
UART
107
WIRELESS COMMUNICATION MODULE
242
OUTPUT UNIT
108
MOTOR DRIVER
109
MOTOR
110
WHEEL TRAIN MECHANISM
111
HAND/DATE-WHEEL SET

FIG. 18

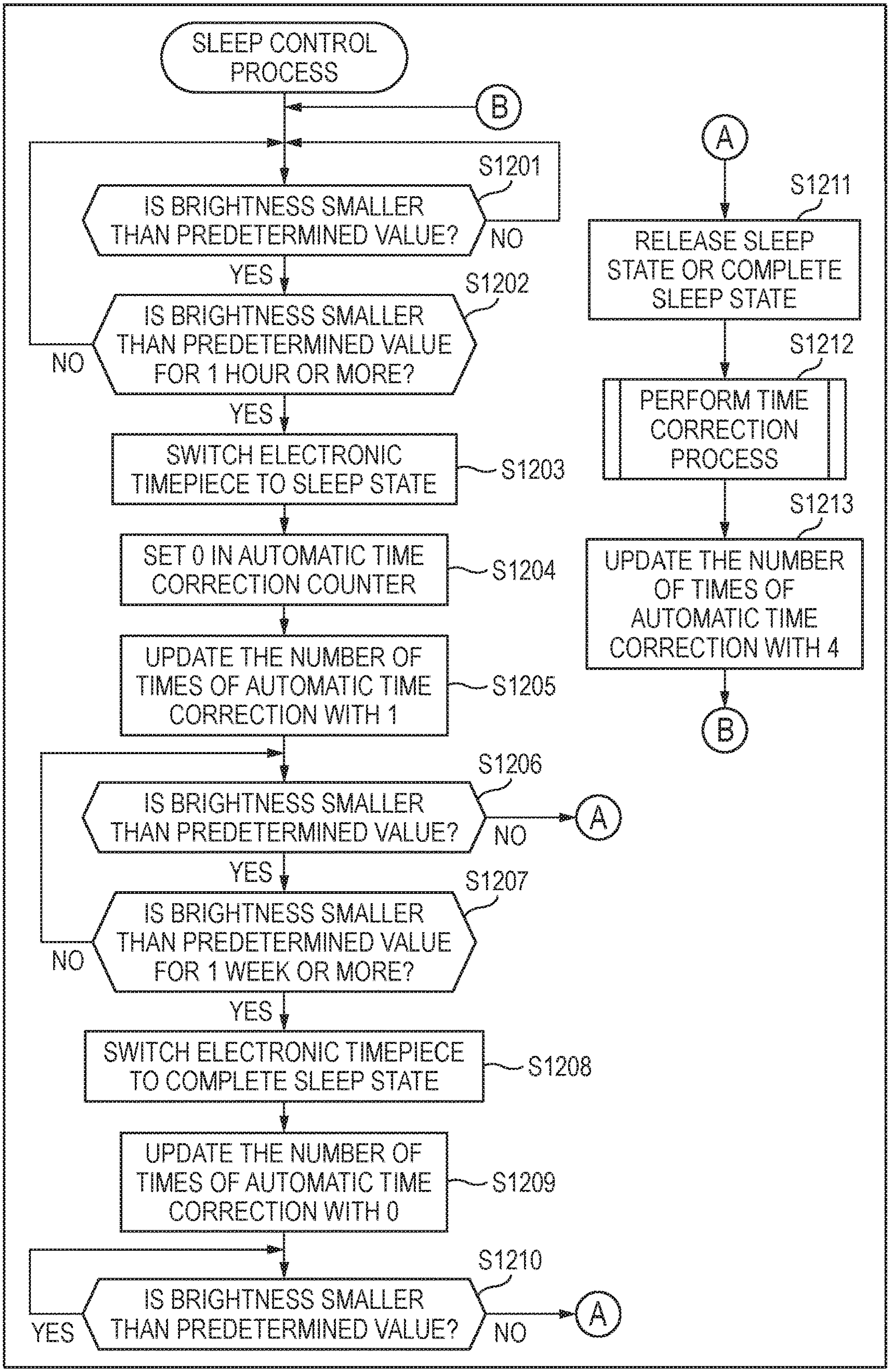

SLEEP CONTROL PROCESS
B
S1201
IS BRIGHTNESS SMALLER THAN PREDETERMINED VALUE?
NO
YES
S1202
IS BRIGHTNESS SMALLER THAN PREDETERMINED VALUE FOR 1 HOUR OR MORE?
NO
YES
SWITCH ELECTRONIC TIMEPIECE TO SLEEP STATE
S1203
SET 0 IN AUTOMATIC TIME CORRECTION COUNTER
S1204
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 1
S1205
S1206
IS BRIGHTNESS SMALLER THAN PREDETERMINED VALUE?
NO
A
YES
S1207
IS BRIGHTNESS SMALLER THAN PREDETERMINED VALUE FOR 1 WEEK OR MORE?
NO
YES
SWITCH ELECTRONIC TIMEPIECE TO COMPLETE SLEEP STATE
S1208
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 0
S1209
S1210
IS BRIGHTNESS SMALLER THAN PREDETERMINED VALUE?
YES
NO
A
A
S1211
RELEASE SLEEP STATE OR COMPLETE SLEEP STATE
S1212
PERFORM TIME CORRECTION PROCESS
S1213
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4
B

FIG. 19

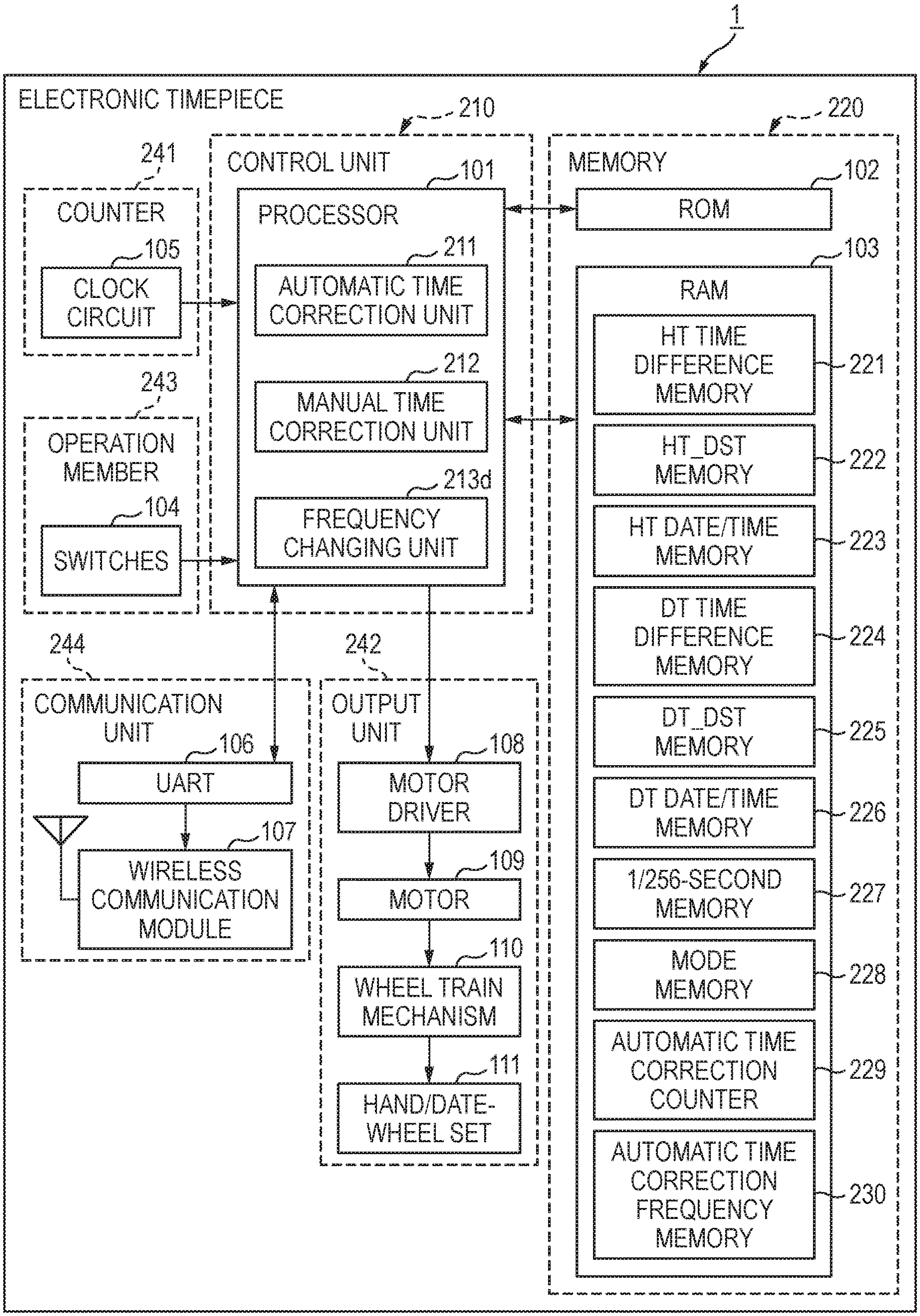

1
ELECTRONIC TIMEPIECE
210
CONTROL UNIT
220
MEMORY
241
COUNTER
105
CLOCK CIRCUIT
101
PROCESSOR
211
AUTOMATIC TIME CORRECTION UNIT
212
MANUAL TIME CORRECTION UNIT
213d
FREQUENCY CHANGING UNIT
102
ROM
103
RAM
HT TIME DIFFERENCE MEMORY
221
HT_DST MEMORY
222
HT DATE/TIME MEMORY
223
DT TIME DIFFERENCE MEMORY
224
DT_DST MEMORY
225
DT DATE/TIME MEMORY
226
1/256-SECOND MEMORY
227
MODE MEMORY
228
AUTOMATIC TIME CORRECTION COUNTER
229
AUTOMATIC TIME CORRECTION FREQUENCY MEMORY
230
243
OPERATION MEMBER
104
SWITCHES
244
COMMUNICATION UNIT
106
UART
107
WIRELESS COMMUNICATION MODULE
242
OUTPUT UNIT
108
MOTOR DRIVER
109
MOTOR
110
WHEEL TRAIN MECHANISM
111
HAND/DATE-WHEEL SET

FIG. 20

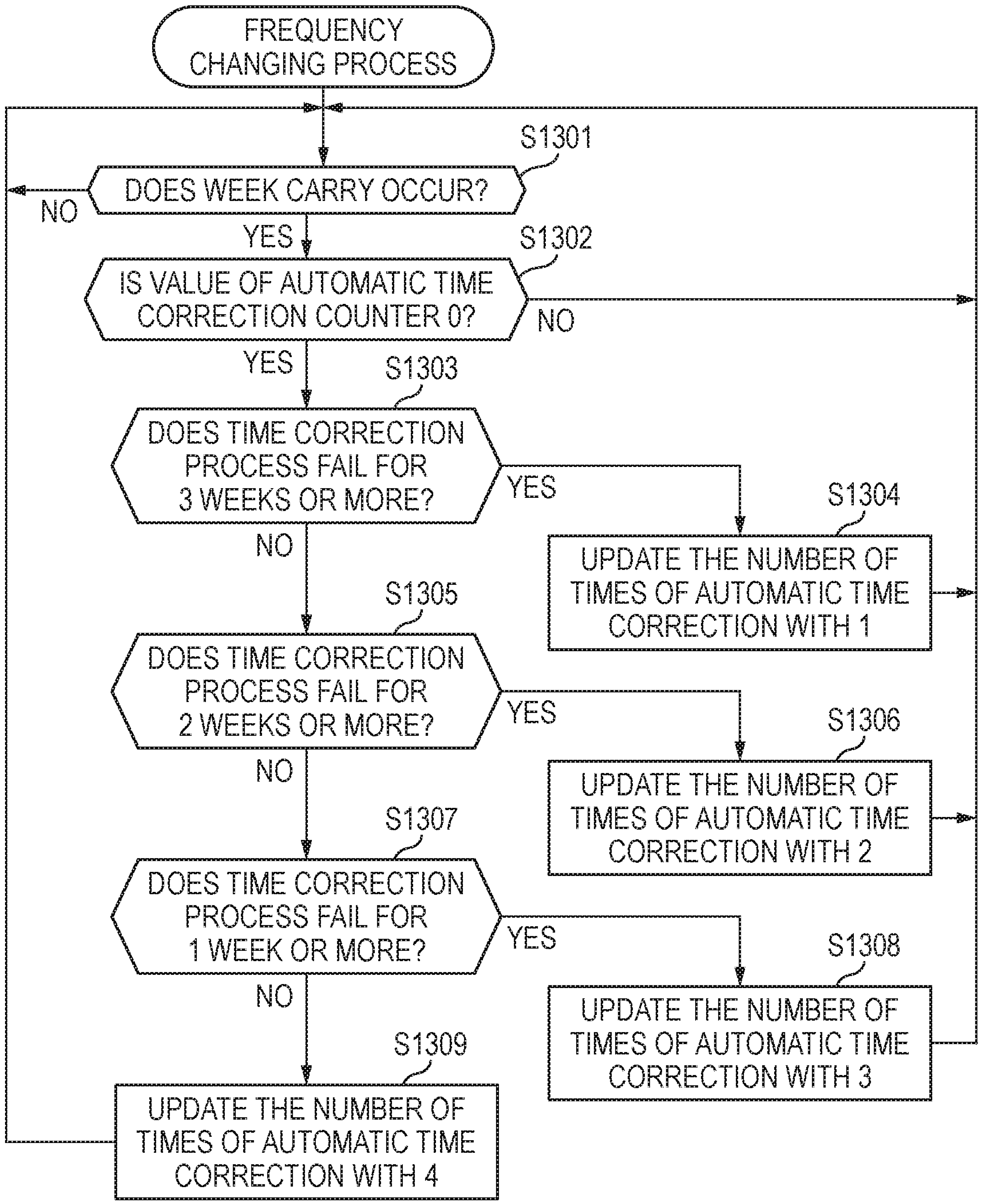
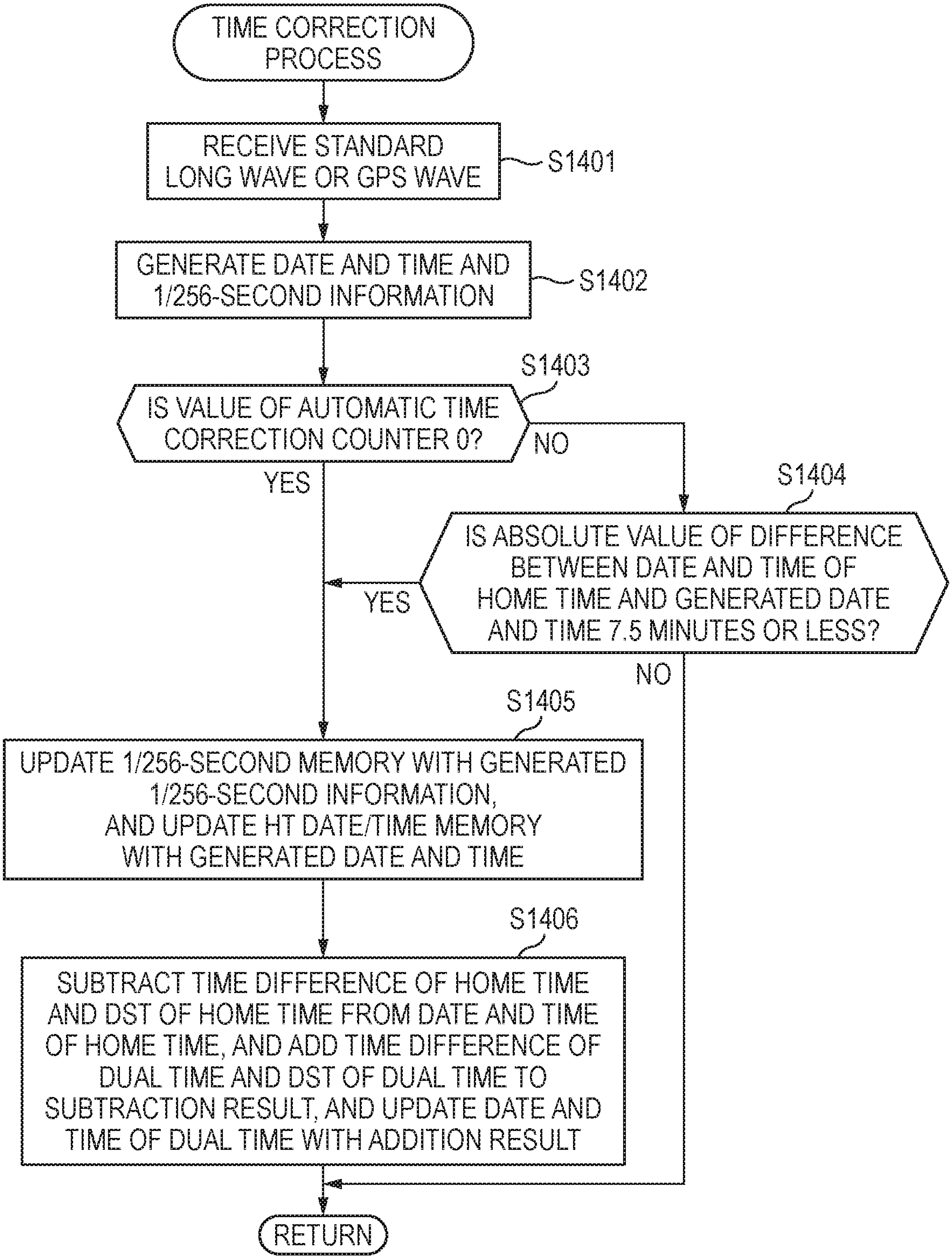

FREQUENCY CHANGING PROCESS
S1301
DOES WEEK CARRY OCCUR?
NO
YES
S1302
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S1303
DOES TIME CORRECTION PROCESS FAIL FOR 3 WEEKS OR MORE?
YES
S1304
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 1
NO
S1305
DOES TIME CORRECTION PROCESS FAIL FOR 2 WEEKS OR MORE?
YES
S1306
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 2
NO
S1307
DOES TIME CORRECTION PROCESS FAIL FOR 1 WEEK OR MORE?
YES
S1308
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 3
NO
S1309
UPDATE THE NUMBER OF TIMES OF AUTOMATIC TIME CORRECTION WITH 4

FIG. 21


TIME CORRECTION PROCESS
RECEIVE STANDARD LONG WAVE OR GPS WAVE
S1401
GENERATE DATE AND TIME AND 1/256-SECOND INFORMATION
S1402
S1403
IS VALUE OF AUTOMATIC TIME CORRECTION COUNTER 0?
NO
YES
S1404
IS ABSOLUTE VALUE OF DIFFERENCE BETWEEN DATE AND TIME OF HOME TIME AND GENERATED DATE AND TIME 7.5 MINUTES OR LESS?
YES
NO
S1405
UPDATE 1/256-SECOND MEMORY WITH GENERATED 1/256-SECOND INFORMATION, AND UPDATE HT DATE/TIME MEMORY WITH GENERATED DATE AND TIME
S1406
SUBTRACT TIME DIFFERENCE OF HOME TIME AND DST OF HOME TIME FROM DATE AND TIME OF HOME TIME, AND ADD TIME DIFFERENCE OF DUAL TIME AND DST OF DUAL TIME TO SUBTRACTION RESULT, AND UPDATE DATE AND TIME OF DUAL TIME WITH ADDITION RESULT
RETURN

COMMUNICATION DEVICE, ELECTRONIC TIMEPIECE, COMMUNICATION METHOD, AND RECORDING MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority under 35 USC 119 of Japanese Patent Application No. 2017-051447 filed on Mar. 16, 2017, the entire disclosure of which, including the description, claims, drawings, and abstract, is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention

The present invention relates to a communication device, an electronic timepiece, a communication method, and a recording medium.

2. Description of the Related Art

Electronic timepieces having a function of accessing a mobile phone such as a smart phone or a feature phone by near field communication and automatically correcting the time are known. For example, JP-A-2009-118403 discloses a time correction system, a portable phone set, and a wristwatch type portable phone terminal for connecting a portable phone and the wristwatch type terminal is connected by Bluetooth (registered as a trade mark) and adjusting the clock of the wristwatch type with reference to the clock of the portable phone. Also, recently, electronic timepieces configured to automatically perform time correction using Bluetooth (registered as a trade mark) Low Energy (BLE) instead of Bluetooth (registered as a trade mark) have begun to appear. Such an electronic timepiece tends to increase the frequency of automatic time correction in order to display the local time in a foreign destination as soon as a user arrives at the destination by plane.

A wristwatch type terminal as disclosed in the above-mentioned Patent Document automatically accesses a portable phone several times a day such that if a user moves to another time zone, the time can be quickly changed. Meanwhile, since the time is accurate within about 15 seconds per month, for a user who do not frequently move from a time zone to another time zone, it is unnecessary to perform automatic time correction several times a day, and due to unnecessary automatic time correction, a lot of power is wasted.

SUMMARY

A communication device, an electronic timepiece, a communication method, and a recording medium are disclosed.

According to one aspect of this disclosure, a communication device includes a receiver, a counter, an operation member and a processor. The receiver receives an external time from an external device. The counter clocks time. The operation member receives a time correction operation from a user to correct the time clocked by the counter. The processor controls the receiver to receive the external time, and to correct the time clocked by the counter to the received external time. The processor sets a frequency at which the time correction process is performed after the operation member receives the time correction operation, higher than a frequency at which the time correction process is performed before the operation member receives the time correction operation, until a predetermined time elapses. In the time correction process, when the difference between the time clocked by the counter and the external time received by the receiver is within a predetermined range, the processor corrects the time clocked by the counter to the external time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view illustrating an example of the configuration of an electronic timepiece according to a first embodiment.

FIG. **2** is a block diagram illustrating the configuration of the electronic timepiece according to the first embodiment.

FIG. **3** is a flow chart illustrating the control procedure of a reset process which is performed by a control unit of the electronic timepiece according to the first embodiment.

FIG. **4** is a flow chart illustrating the control procedure of a manual time correction process which is performed by the control unit of the electronic timepiece according to the first embodiment.

FIG. **5** is a flow chart illustrating the control procedure of a count process which is performed by the control unit of the electronic timepiece according to the first embodiment.

FIG. **6** is a flow chart illustrating the control procedure of an automatic time correction process which is performed by the control unit of the electronic timepiece according to the first embodiment.

FIG. **7** is a flow chart illustrating the control procedure of a time correction process which is performed by the control unit of the electronic timepiece according to the first embodiment.

FIG. **8** is a block diagram illustrating the configuration of an electronic timepiece according to a second embodiment.

FIG. **9** is a view illustrating examples of data items which are stored in a city/time-difference memory according to the second embodiment.

FIG. **10** is a flow chart illustrating the control procedure of a time correction process which is performed by a control unit of the electronic timepiece according to the second embodiment.

FIG. **11** is a flow chart illustrating the control procedure of a time connection process which is performed by a control unit of an electronic timepiece according to a third embodiment.

FIG. **12** is a flow chart illustrating the control procedure of a frequency changing process which is performed by a control unit of an electronic timepiece according to a fourth embodiment.

FIG. **13** is a flow chart illustrating the control procedure of an automatic time correction process which is performed by the control unit of the electronic timepiece according to the fourth embodiment.

FIG. **14** is a block diagram illustrating the functional configuration of an electronic timepiece according to a fifth embodiment.

FIG. **15** is a flow chart illustrating the control procedure of a battery voltage detecting process which is performed by a control unit of the electronic timepiece according to the fifth embodiment.

FIG. **16** is a flow chart illustrating the control procedure of an automatic time correction process which is performed by the control unit of the electronic timepiece according to the fifth embodiment.

FIG. **17** is a block diagram illustrating the functional configuration of an electronic timepiece according to a sixth embodiment.

FIG. **18** is a flow chart illustrating the control procedure of a sleep control process which is performed by a control unit of the electronic timepiece according to the sixth embodiment.

FIG. **19** is a block diagram illustrating the functional configuration of an electronic timepiece according to a seventh embodiment.

FIG. **20** is a flow chart illustrating the control procedure of a frequency changing process which is performed by a control unit of the electronic timepiece according to the seventh embodiment.

FIG. **21** is a flow chart illustrating the control procedure of a time correction process which is performed by a control unit of an electronic timepiece according to a modification.

DETAILED DESCRIPTION

Hereinafter, embodiments will be described with reference to the accompanying drawings.

First Embodiment

FIG. **1** is a view illustrating the external appearance of an electronic timepiece **1** (a communication device) according to a first embodiment of the present invention. The electronic timepiece **1** includes a case **10** having a top configured with a windshield, and a crown **21** and push button switches **22** to **25** disposed on the side surface of the case **10**. Also, inside the case **10**, a dial plate **31**, various hands (an hour hand **32**, a minute hand **33**, and a second hand **34**), and a date wheel **35** are provided so as to be visible through the windshield. The dial plate **31** has markings and gradations to indicate time. The individual hands (the hour hand **32**, the minute hand **33**, and the second hand **34**) rotate on the dial plate **31** to indicate the current time in a first region, i.e. the current time (local time) in the first region. The date wheel **35** displays the current date. In the following description, the time which is indicated by the hands (the hour hand **32**, the minute hand **33**, and the second hand **34**) will also be referred to as the home time.

Further, a small timepiece **40** is provided in the direction of 9 o'clock on the dial plate **31**. The small timepiece **40** includes a dial plate **41** and various hands (an hour hand **42** and a minute hand **43**). The individual hands (the hour hand **42** and the minute hand **43**) can rotate on the dial plate **41** to indicate a time (for example, a local time in a second region) different from the home time. In the following description, the time which is indicated by the hands (the hour hand **42** and the minute hand **43**) of the small timepiece **40** will also be referred to as the dual time.

The crown **21** and the push button switches **22** to **25** each receive input operations from a user. The crown **21** can be pulled out in two stages from the case **10**, and by pulling out the crown to a position corresponding to the second stage and rotating the crown, the user can manually correct the time difference between the time of the home time and Coordinated Universal Time (UTC). The push button switches **22** to **25** can be operated to change a correction mode, switch to or from daylight saving time, interchange the home time and the dual time, access an external device, and perform other operations.

Now, the hardware configuration of the electronic timepiece **1** will be described. As shown in FIG. **2**, the electronic timepiece **1** includes a processor **101**, a read only memory (ROM) **102**, a random access memory (RAM) **103**, switches **104**, a clock circuit **105**, a universal asynchronous receiver transmitter (UART) **106**, a wireless communication module **107**, a motor driver **108**, a motor **109**, a wheel train mechanism **110**, and a hand/date-wheel set **111**.

The processor **101** generally controls the whole of the electronic timepiece **1** by executing various control programs. In the ROM **102**, the control programs to be executed by the processor **101**, and a variety of data necessary to execute the control programs are stored in advance. The RAM **103** is configured to store a variety of data generated or changed during execution of the control programs, and functions a work space which the processor **101** can use to work.

The switches **104** receive input operations from the user, and output electric signals according to the input operations. The switches **104** include the crown **21** and the push button switches **22** to **25** described above.

The clock circuit **105** includes a crystal oscillator, a frequency divider circuit, and the like, and clocks the current date and time by counting the number of signals acquired from the frequency divider circuit, and outputs the clocked result to the processor **101**.

The UART **106** performs conversion between parallel signals which the processor **101** handles and serial signals which the wireless communication module **107** handles. The wireless communication module **107** includes an antenna, one of a pair of a transmitter and a receiver, a transceiver, and a communication circuit for radio frequency (RF), a baseband (BB) circuit, a memory circuit, and other circuits, and performs data communication with an external communication device such as a smart phone. An automatic time correction process to be described below is performed via the wireless communication module **107**.

The motor driver **108** outputs drive pulse signals to the motor **109** on the basis of instructions from the processor **101**. The motor **109** is a stepping motor, and drives the wheel train mechanism **110** according to drive pulses input from the motor driver **108**. However, the motor **109** may be configured with a motor other than stepping motors.

The wheel train mechanism **110** is configured with a combination of a plurality of gears. According to rotation of the motor **109**, the wheel train mechanism **110** rotates the hands and the date wheel included in the hand/date-wheel set **111** by predetermined angles, respectively. In general, a plurality of motors **109**, a plurality of wheel train mechanisms **110**, and a plurality of hand/date-wheel sets **111** are provided for various types of hands and date wheels, respectively.

For example, whenever the processor **101** rotates a motor **109** for the hour hand once by two minutes, the hour hand of the hand/date-wheel set **111** is rotated 1 degree by the wheel train mechanism **110** for the hour hand. Also, whenever the processor **101** rotates a motor **109** for the minute hand once by one second, the second hand of the hand/date-wheel set **111** is rotated 0.1 degrees by the wheel train mechanism **110** for the minute hand. Further, whenever the processor **101** rotates a motor **109** for the dual time for 60 seconds, by the wheel train mechanism **110** for the dual time, the minute hand of the hand/date-wheel set **111** of the small timepiece **40** is rotated 6 degrees and the minute hand of the hand/date-wheel set **111** is rotated 0.5 degrees.

Although the case where the electronic timepiece **1** is an analog timepiece configured such that hands and a date wheel move mechanically has been described above, the electronic timepiece **1** may be a digital timepiece configured to display date and time on a display screen configured with a display device such as a liquid crystal display, an organic electro-luminescence (EL) display, or the like. For example, in the case where the electronic timepiece **1** is a digital timepiece having a liquid crystal screen, the electronic timepiece includes a liquid crystal driver and a liquid crystal display, in place of the motor driver **108**, the motor **109**, the wheel train mechanism **110**, and the hand/date-wheel set **111**, and the processor **101** controls the liquid crystal display via the liquid crystal driver such that the liquid crystal display displays the current time.

Now, the functional configuration of the electronic timepiece **1** will be described. As shown in FIG. **2**, the electronic timepiece **1** includes a control unit **210**, a memory **220**, a counter **241**, an output unit **242**, an operation member **243**, and a communication unit **244**.

The control unit **210** includes the processor **101** such as a central processing unit (CPU), and implements the functions of individual units of the electronic timepiece **1** (an automatic time correction unit **211**, a manual time correction unit **212**, and a frequency changing unit **213**) by executing programs stored in the memory **220**. The functions of the automatic time correction unit **211**, the manual time correction unit **212**, and the frequency changing unit **213** may be implemented by a single processor or the control unit **210**, or processors or control units **210** may be provided for the corresponding units, respectively, and implement the functions of the corresponding units, respectively.

The control unit **210** which functions as the automatic time correction unit **211** performs a time correction process of correcting the time clocked by the counter **241**. In the present embodiment, the control unit **210** receives the time of an external device such as a smart phone by performing communication with the external device via the communication unit **244**, at a frequency stored in an automatic time correction frequency memory **230** to be described below. If the difference between the time of the home time stored in the memory **220** and the external time received by the communication unit **244** is within a predetermined range (for example, between −7.5 minutes and 7.5 minutes), the control unit **210** corrects the time of the home time stored in the memory **220**, to the external time.

In the case where the control unit **210** functions as the manual time correction unit **212**, if a user's time correction operation is received by the operation member **243**, the control unit corrects the time clocked by the counter **241**, on the basis of the received time correction operation. In the present embodiment, the operation member **243** receives an operation for correcting the time clocked by the counter **241** to a time designated by the user, as a time correction operation. Then, the control unit **210** corrects the time of the home time stored in the memory **220** to the time designated by the user.

In the case where the control unit **210** functions as the frequency changing unit **213**, if the operation member **243** receives a time correction operation, the control unit sets a frequency at which the time correction process should be performed, higher than that before the reception of the time correction operation, until a predetermined time (for example, 24 hours) elapses. In the present embodiment, if the operation member **243** receives a time correction operation, the control unit **210** sets 24 in an automatic time correction counter **229** (to be described below), and counts 24 hours as the predetermined time by subtracting 1 from the value of the automatic time correction counter **229** whenever one hour elapses. Also, if the operation member **243** receives the time correction operation, the control unit **210** updates the number of times of automatic time correction per day stored in the automatic time correction frequency memory **230** (to be described below) with 24, thereby changing the frequency at which the time correction process should be performed such that time correction is performed 24 times a day, in other words, at intervals of one hour. Further, if the value of the automatic time correction counter **229** becomes 0, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4, thereby changing the frequency at which the time correction process should be performed such that time correction is performed 4 times a day, in other words, at intervals of six hours.

The memory **220** includes the ROM **102**, the RAM **103**, and the like. The RAM **103** includes: a home time (HT) time difference memory **221** for storing the time difference of the home time (the time difference between the home time and Coordinated Universal Time (UTC)); an HT_DST (daylight saving time) memory **222** for storing the daylight saving time information of the home time; an HT date/time memory **223** for storing the date (year, month, and day) and the time (hours, minutes, and seconds) of the home time; a dual time (DT) time difference memory **224** for storing the time difference of the dual time (the time difference between the dual time and Coordinated Universal Time (UTC)); a DT_DST memory **225** for storing the daylight saving time of the dual time; a DT date/time memory **226** for storing the date (year, month, and day) and the time (hours, minutes, and seconds) of the dual time; a 1/256-second memory **227** for storing 1/256-second information (in units of 1/256 seconds) less than one second and usable in common by the home time and the dual time; a mode memory **228** for storing the current mode of the electronic timepiece **1** (such as a normal mode, a time correction mode, or the like); the automatic time correction counter **229** for counting the predetermined time if the operation member **243** receives a time correction operation; and the automatic time correction frequency memory **230** for storing the number of times of automatic time correction per day the time correction process should be performed.

The time differences which are stored in the HT time difference memory **221** and the DT time difference memory **224** can have values in a range between −12 hours and +14 hours. The daylight saving time information items which are stored in the HT_DST memory **222** and the DT_DST memory **225** can have 0 (standard time) or +1 hour (daylight saving time). The values which are stored in the HT date/time memory **223** and the DT date/time memory **226** are years, months, days, hours, minutes, and seconds. The value stored in the 1/256-second memory **227** is increased by 1 at intervals of 1/256 seconds by a clocking process of the counter **241** and the control unit **210** to be described below. Further, after the value stored in the 1/256-second memory **227** becomes 255, when 1/256 seconds elapses, the value stored in the 1/256-second memory **227** is updated with 0, and the second information item of the home time stored in the HT date/time memory **223** and the second information item of the dual time stored in the DT date/time memory **226** each are increased by 1. In addition, after the second information items of the home time and the dual time become 59 seconds, when 1 second elapses, the individual second information items are updated with 0, and the minute information items are increased by 1. The same is true for minute information and hour information.

The counter **241** includes the clock circuit **105**, and clocks the current time, and outputs the clocked result to the control unit **210**. On the basis of the clocked result input from the counter **241**, the control unit **210** performs a clocking process of updating information stored in the HT date/time memory **223**, the DT date/time memory **226**, and 1/256-second memory **227** of the memory **220**. However, the function of the counter **241** may be implemented by the control unit **210**.

The output unit **242** includes a time display unit. The time display unit includes the motor driver **108**, the motor **109**, the wheel train mechanism **110**, and the hand/date-wheel set **111**, and indicates the current time. In the case where the electronic timepiece **1** is a digital timepiece having a liquid crystal display unit, the time display unit includes a liquid crystal driver and a liquid crystal display device.

The operation member **243** has the switches **104** including the crown **21** and the push button switches **22** to **25**. In the present embodiment, the operation member **243** receives a time correction operation of the user for correcting the time clocked by the counter **241**. For example, a time correction operation is an operation for correcting the time of the home time to a time designated by the user, such as an operation for interchanging the home time and the dual time, an operation for switching to or from daylight saving time, an operation for correcting the time difference of the home time, and an operation for correcting the date and time of the home time.

The communication unit **244** includes the wireless communication module **107**, and performs data communication with an external device such as a smart phone. The contents of data communication include requesting to transmit time difference information and daylight saving time information for time correction, receiving information on time difference information and daylight saving time information for time correction, requesting to transmit date-and-time information and 1/256-second information, receiving date-and-time information and 1/256-second information, receiving a command for a remote operation, and so on.

Now, a reset process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **3**. The reset process is a process of setting the number of times of automatic time correction stored in the automatic time correction counter **229** and the automatic time correction frequency memory **230** to an initial value, and is started, for example, if the power of the electronic timepiece **1** is turned on.

If the reset process is started, in STEP S**101**, the control unit **210** sets 0 in the automatic time correction counter **229**. Subsequently, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4 in STEP S**102**, and finishes the reset process.

By the above-described process, in an initial state, the control unit **210** sets the frequency at which the time correction process should be performed to 4 times per day. However, the frequency at which the time correction process should be performed in the initial state is not limited to 4 times per day, and the number of times can be arbitrarily set.

Now, a manual time correction process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **4**. This process is started if the operation member **243** receives a time correction operation from the user.

First, in STEP S**201**, the control unit **210** acquires the operation content of the time correction operation recognized by the operation member **243**. Subsequently, in STEP S**202**, the control unit **210** corrects the time of the home time stored in the HT date/time memory **223**, according to the acquired operation content. Then, in STEP S**203**, the control unit **210** sets 24 in the automatic time correction counter **229**. Subsequently, the control unit **210** updates the automatic time correction frequency memory **230** with 24 in STEP S**204**, and finishes the process.

After the time correction operation is received, by the above-described process, the control unit **210** increases the number of times per day the time correction process should be performed, from 4 times to 24 times, until the predetermined time (24 hours) elapses. However, the predetermined time is not limited to 24 hours, and an arbitrary time can be set. Also, the frequency at which the time correction process should be performed in the predetermined time is not limited to 24 times per day, and the number of times larger than the number of times in the initial state can be arbitrarily set.

Now, a count process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **5**. In order to count 24 hours by the automatic time correction counter **229**, the control unit **210** performs the count process if an hour carry (start of a new hour at 1 second from 59 minutes and 59 seconds of each hour) occurs in the course of the clocking process of the electronic timepiece **1**.

First, in STEP S**301**, the control unit **210** determines whether an hour carry (start of a new hour) has occurred. In the case where an hour carry has occurred ("Yes" in STEP S**301**), in STEP S**302**, the control unit **210** determines whether the value of the automatic time correction counter **229** is larger than 0. In the case where the value of the automatic time correction counter **229** is larger than 0 ("Yes" in STEP S**302**), in STEP S**303**, the control unit **210** decreases the value of the automatic time correction counter **229** by 1.

Subsequently, in STEP S**304**, the control unit **210** determines whether the value of the automatic time correction counter **229** is 0. In the case where the value of the automatic time correction counter **229** is 0 ("Yes" in STEP S**304**), in STEP S**305**, the control unit updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4. Then, the control unit **210** returns to STEP S**301**, and stands by until an hour carry occurs.

In the case where an hour carry has not occurred ("No" in STEP S**301**), and the value of the automatic time correction counter **229** is equal to or smaller than 0 ("No" in STEP S**302**), and the value of the automatic time correction counter **229** is not 0 ("No" in STEP S**304**), the control unit **210** returns to STEP S**301**, and stands by until an hour carry occurs.

By the above-described process, the control unit **210** counts the time elapsed after reception of a time correction operation, in units of one hour, by the automatic time correction counter **229**. Also, if 24 hours elapses after reception of a time correction operation, the control unit **210** returns the number of times of automatic time correction to 4 times per day.

Now, the automatic time correction process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **6**. This process is a process of accessing the external device at a frequency represented by the number of times of automatic time correction stored in the automatic time correction frequency memory **230** and automatically adjusting the time of the home time of the electronic timepiece **1** to the time (the external time) of the external device.

First, in STEP S**401**, the control unit **210** determines whether a minute carry (start of a new minute at 1 second from 59 seconds of each minute) has occurred. In the case where a minute carry has occurred ("Yes" in STEP S**401**), in

STEP S**402**, the control unit **210** determines whether the number "n" of times of automatic time correction stored in the automatic time correction frequency memory **230** is 4 or 24. In the case where a minute carry has not occurred ("No" in STEP S**401**), the control unit **210** stands by until a minute carry occurs.

In the case where the number "n" of times of automatic time correction is 4 ("n=4" in STEP S**402**), in STEP S**403**, the control unit **210** determines whether the time (hours and minutes) of the home time stored in the HT date/time memory **223** is any one of 05:02, 11:02, 17:02, and 23:02. In the case where the time (hours and minutes) of the home time is one of 05:02, 11:02, 17:02, and 23:02 ("Yes" in STEP S**403**), in STEP S**405**, the control unit **210** performs the time correction process. In the case where the time (hours and minutes) of the home time is not one of 05:02, 11:02, 17:02, and 23:02 ("No" in STEP S**403**), the control unit **210** returns to STEP S**401**, and stands by until a minute carry occurs.

In the case where the number "n" of times of automatic time correction is 24 ("n=24" in STEP S**402**), in STEP S**404**, the control unit **210** determines whether the time (minutes) of the home time stored in the HT date/time memory **223** is 02. In the case where the time (minutes) of the home time is 02 ("Yes" in STEP S**404**), in STEP S**405**, the control unit **210** performs the time correction process. In the case where the time (minutes) of the home time is not 02 ("No" in STEP S**404**), the control unit **210** returns to STEP S**401**, and stands by until a minute carry occurs.

Now, the time correction process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **7**. First, in STEP S**501**, the control unit **210** performs a connection process for establishing a connection with the external device via the communication unit **244**.

Subsequently, in STEP S**502**, the control unit **210** requests the external device to transmit time difference information and daylight saving time (DST) information. If the external device receives that request, it transmits time difference information and daylight saving time (DST) information which the external device has, to the electronic timepiece **1** having requested. Then, in STEP S**503**, the control unit **210** receives the time difference information and the daylight saving time (DST) information transmitted by the external device, via the communication unit **244**.

Subsequently, in STEP S**504**, the control unit **210** requests the external device to transmit date-and-time information and 1/256-second information, via the communication unit **244**. If the external device receives that request, it transmits date-and-time information and 1/256-second information which the external device has, to the electronic timepiece **1** having requested. Then, in STEP S**505**, the control unit **210** receives the date-and-time information and the 1/256-second information transmitted by the external device, via the communication unit **244**.

Subsequently, in STEP S**506**, the control unit **210** determines whether the value of the automatic time correction counter **229** is 0. In the case where the value of the automatic time correction counter **229** is not 0 ("No" in STEP S**506**), in STEP S**507**, the control unit determines whether the absolute value of the difference between the date and time of the home time stored in the HT date/time memory **223** and the received date and time is 7.5 minutes or less, or not. In the case where the absolute value is not 7.5 minutes or less ("No" in STEP S**507**), the control unit proceeds to STEP S**510**.

In the case where the value of the automatic time correction counter **229** is 0 ("Yes" in STEP S**506**), or in the case where the absolute value of the difference between the date and time of the home time stored in the HT date/time memory **223** and the received date and time is 7.5 minutes or less ("Yes" in STEP S**507**), in STEP S**508**, the control unit **210** updates the 1/256-second memory **227** with the received 1/256-second information, and updates the HT date/time memory **223** with the received date and time, and updates the HT_DST memory **222** with the received daylight saving time information, and updates the HT time difference memory **221** with the received time difference.

Next, in STEP S**509**, the control unit **210** calculates Coordinated Universal Time (UTC) by subtracting the time difference stored in the HT time difference memory **221** and the daylight saving time information stored in the HT_DST memory **222** from the date and time of the home time stored in the HT date/time memory **223**, and obtains the date and time of the dual time by adding the time difference stored in the DT time difference memory **224** and the daylight saving time information stored in the DT_DST memory **225** to the Coordinated Universal Time (UTC), and stores the obtained date and time in the DT date/time memory **226**. Then, the control unit **210** performs a disconnection process for terminating the connection with the external device, in STEP S**510**, and returns to STEP S**401** of FIG. **6**.

In the case where the frequency at which the time correction process should be performed has been set to 4 times per day, by the above-described process, the control unit **210** accesses the external device once every 6 hours, and corrects the time of the home time to an external time received from the external device. Also, in the case where the frequency at which the time correction process should be performed has been set to 24 times per day, the control unit **210** accesses the external device once every hour, and corrects the time of the home time to an external time received from the external device. In the above-described example, in the case where the number of times of automatic time correction per day is 4, 05:02, 11:02, 17:02, and 23:02 every day are set as timings at which the time correction process should be performed; whereas in the case where the number of times of automatic time correction per day is 24, 02 minutes past the hour are set as timings at which the time correction process should be performed.

However, timings at which the time correction process should be performed may be arbitrarily set. By the way, at 00 minutes past the hour, the electronic timepiece **1** is likely to be in a state where it should perform many processes due to time signal processing. For this reason, it is preferable to set timings at which the time correction process should be performed to timings other than 00 minutes past the hour.

As described above, after the operation member **243** receives a time correction operation, the control unit **210** of the electronic timepiece **1** according to the present embodiment sets a frequency at which the time correction process should be performed, higher than that before the reception of the time correction operation, until the predetermined time elapses. Therefore, after the user manually corrects the time of the electronic timepiece **1**, even if the user moves to another time zone, it is possible to quickly correct the time of the electronic timepiece **1** to a time suitable for the user. Also, if the predetermined time elapses after reception of a time correction operation, the control unit **210** of the electronic timepiece **1** sets the original frequency again. Therefore, it is possible to suppress power consumption from increasing due to the time correction process.

Also, in the present embodiment, the operation member **243** receives an operation for correcting the time clocked by the counter **241** to a time designated by the user, as a time correction operation. Therefore, after the time clocked by the counter **241** is corrected to a time designated by the user, even if the user moves to another time zone, it is possible to quickly correct the time of the electronic timepiece to a time suitable for the user.

Second Embodiment

In the first embodiment, the example in which the control unit increases the frequency at which the time correction process should be performed for the predetermined time if the user manually corrects the time of the home time of the electronic timepiece **1** has been described as an example. In the second embodiment, an example in which the control unit changes the frequency at which the time correction process should be performed if the user manually performs correction to a city corresponding to the time difference of the home time of the electronic timepiece **1** from Coordinated Universal Time (UTC) will be described. In the following description, components identical to those of the first embodiment are denoted by the same reference symbols, and a detailed description thereof will not be made.

The functional configuration of an electronic timepiece **1** according to the second embodiment will be described. As shown in FIG. **8**, in the electronic timepiece **1**, the memory **220** further includes a city/time-difference memory **231** for storing the correspondence relation between cities and time differences, in addition to the components of the memory **220** of the first embodiment shown in FIG. **2**. Also, the control unit **210** functions as an automatic time correction unit **211***a* and a manual time correction unit **212***a*, instead of the automatic time correction unit **211** and the manual time correction unit **212** of the first embodiment.

FIG. **9** shows examples of data items which are stored in the city/time-difference memory **231**. As shown in FIG. **9**, in the city/time-difference memory **231**, city codes representing cities, and time differences of the times in the corresponding cities from Coordinated Universal Time (UTC) are stored in association with each other.

The control unit **210** which functions as the automatic time correction unit **211***a* performs the time correction process of correcting the time clocked by the counter **241**. In the present embodiment, at the frequency stored in the automatic time correction frequency memory **230** to be described below, the control unit **210** receives the time (external time) of the external device such as a smart phone and the time difference from Coordinated Universal Time (UTC) by communication with the external device via the communication unit **244**. If the time difference received by the communication unit **244** is the same as the time difference stored in the HT time difference memory **221**, the control unit **210** corrects the time of the home time stored in the memory **220** to the external time.

If the operation member **243** receives a user's city correction operation for performing correction to a city corresponding to the time clocked by the counter **241**, on the basis of the corrected city, the control unit **210** which functions as the manual time correction unit **212***a* corrects the time difference of the home time stored in the HT time difference memory **221**, and the date and time of the home time stored in the HT date/time memory **223**. In the present embodiment, the control unit **210** specifies a time difference corresponding to a city code representing the city received by the operation member **243**, with reference to the city/time-difference memory **231**, and corrects the time difference stored in the HT time difference memory **221** to the specified time difference.

Now, the time correction process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **10**. The control unit **210** performs processes identical to STEPS S**501** to S**506** and STEPS S**508** to S**510** of the time correction process according to the first embodiment shown in FIG. **7**, in STEPS S**601** to S**606** and STEPS S**608** to S**610**.

Also, in STEP S**607**, the control unit **210** determines whether the time difference of the home time stored in the HT time difference memory **221** is the same as the received time difference. In the case of determining that the time difference of the home time is the same as the received time difference, the control unit **210** proceeds to STEP S**608**. Meanwhile, in the case of determining that the time difference of the home time is not the same as the received time difference, the control unit **210** proceeds to STEP S**610**.

Also, in the above-described process, if the operation member **243** receives a user's operation of designating a city, the control unit **210** may store a city code corresponding to the designated city, in the memory **220**. Further, the control unit **210** may receive the time (external time) and a city code of an external device such as a smart phone by communication with the external device via the communication unit **244**. In this case, in STEP S**607**, the control unit **210** determines whether the city code stored in the memory **220** is the same as the received city code. In the case where they are the same as each other, the control unit proceeds to STEP S**608**; whereas in the case where they are not the same as each other, the control unit proceeds to STEP S**610**.

As described above, if the operation member **243** receives a city correction operation for performing correction to a city corresponding to the time difference of the home time of the electronic timepiece **1** from Coordinated Universal Time (UTC), the control unit **210** of the electronic timepiece **1** according to the present embodiment sets a frequency at which the time correction process should be performed, higher than that before the reception of the city correction operation, until the predetermined time elapses. Therefore, after the user manually performs correction to a city corresponding to the time difference of the home time of the electronic timepiece **1**, even if the user moves to another time zone, it is possible to quickly perform correction to a time suitable for the user. Also, if the predetermined time elapses from reception of a city correction operation, the control unit **210** sets the original frequency again. Therefore, it is possible to suppress power consumption from increasing due to the time correction process.

Third Embodiment

In the first embodiment, the example in which the operation member **243** receives an operation for correcting the time clocked by the counter **241** to a time designated by the user as a time correction operation has been described. However, the operation member **243** may receive an operation (a time connection operation) for receiving an external time from an external device and correcting the time clocked by the counter **241** to the received external time, as a time correction operation.

A time connection process of an electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **11**. This process is started if the operation member **243** receives a time connection operation from the user.

If the operation member **243** receives a time correction operation, first, in STEP S**701**, the control unit **210** performs the time correction process shown in FIG. **7**. Next, in STEP

S702, the control unit 210 sets 24 in the automatic time correction counter 229. Subsequently, the control unit 210 updates the automatic time correction frequency memory 230 with 24 STEP S703, and finishes the process.

By the above-described process, if a time connection operation is received, the control unit 210 increases the number of times per day the control unit should perform the time correction process, from 4 times to 24 times until the predetermined time (24 hours) elapses. Therefore, after the time connection process is performed, even if the user moves to another time zone, it is possible to quickly perform correction to a time suitable for the user. Also, if the predetermined time elapses from reception of a time connection operation, the control unit 210 of the electronic timepiece 1 sets the original frequency again. Therefore, it is possible to suppress power consumption from increasing due to the time correction process.

Fourth Embodiment

In the first embodiment to the third embodiment described above, the example in which if a time correction operation or a city correction operation is received, the control unit increases the frequency at which the time correction process should be performed until the predetermined time elapses has been described. In the present embodiment, in the case where the communication unit 244 receives a constant time difference for a time longer than the predetermined time, the control unit sets a frequency at which the time correction process should be performed, lower than that before reception of the time correction operation or the city correction operation will be described.

A frequency changing process of an electronic timepiece 1 according to the present embodiment will be described with reference to FIG. 12. The control unit 210 performs the frequency changing process when a month carry (start of a new month at 1 second from 23:59:59 on the last day of each month) occurs in the course of the clocking process of the electronic timepiece 1.

First, in STEP S801, the control unit 210 determines whether a month carry (start of a new month) has occurred. In the case where a month carry has occurred ("Yes" in STEP S801), in STEP S802, the control unit 210 determines whether the value of the automatic time correction counter 229 is 0. In the case where a month carry has not occurred ("No" in STEP S801), or in the case where the value of the automatic time correction counter 229 is not 0 ("No" in STEP S802), the control unit 210 returns to STEP S801.

In the case where the value of the automatic time correction counter 229 is 0 ("Yes" in STEP S802), in STEP S803, the control unit 210 determines whether the time difference stored in the HT time difference memory 221 has remained unchanged for 3 months or more. In the case where the time difference stored in the HT time difference memory 221 has remained unchanged for 3 months or more ("Yes" in STEP S803), the control unit 210 updates the number of times of automatic time correction stored in the automatic time correction frequency memory 230 with 1 in STEP S804, and returns to STEP S801.

In the case where the time difference stored in the HT time difference memory 221 has not remained unchanged for 3 months or more ("No" in STEP S803), in STEP S805, the control unit 210 determines whether the time difference stored in the HT time difference memory 221 has remained unchanged for 2 months or more. In the case where the time difference stored in the HT time difference memory 221 has remained unchanged for 2 months or more ("Yes" in STEP S805), the control unit 210 updates the number of times of automatic time correction stored in the automatic time correction frequency memory 230 with 2 in STEP S806, and returns to STEP S801.

In the case where the time difference stored in the HT time difference memory 221 has not remained unchanged for 2 months or more ("No" in STEP S805), in STEP S807, the control unit 210 determines whether the time difference stored in the HT time difference memory 221 has remained unchanged for 1 month or more. In the case where the time difference stored in the HT time difference memory 221 has remained unchanged for 1 month or more ("Yes" in STEP S807), the control unit 210 updates the number of times of automatic time correction stored in the automatic time correction frequency memory 230 with 3 in STEP S808, and returns to STEP S801.

In the case where the time difference stored in the HT time difference memory 221 has not remained unchanged for 1 month or more ("No" in STEP S807), the control unit 210 updates the number of times of automatic time correction stored in the automatic time correction frequency memory 230 with 4 in STEP S809, and returns to STEP S801.

By the above-described process, after the time difference stored in the HT time difference memory 221 is finally changed, whenever one month passes, the control unit 210 decreases the number of times the time correction process should be performed by 1, thereby decreasing the frequency. Further, after the time difference stored in the HT time difference memory 221 is finally changed, if 3 months pass, the control unit 210 sets the frequency at which the time correction process should be performed, to once per day.

Now, an automatic time correction process of the electronic timepiece 1 according to the present embodiment will be described with reference to FIG. 13. The control unit 210 performs processes identical to STEPS S401 to S405 of the automatic time correction process shown in FIG. 6, in STEPS S901, S902, and S906 to S908, and further performs the following processes of STEPS S903 to S905.

In the case where the number "n" of times of automatic time correction is 1 ("n=1" in STEP S902), in STEP S903, the control unit 210 determines whether the time (HH:MM) of the home time stored in the HT date/time memory 223 is 17:02. In the case where the time (HH:MM) of the home time is 17:02 ("Yes" in STEP S903), in STEP S908, the control unit performs the time correction process. In the case where the time (HH:MM) of the home time is not 17:02 ("No" in STEP S903), the control unit 210 returns to STEP S901, and stands by until a minute carry occurs.

In the case where the number "n" of times of automatic time correction is 2 ("n=2" in STEP S902), in STEP S904, the control unit 210 determines whether the time (HH:MM) of the home time stored in the HT date/time memory 223 is one of 11:02 and 23:02. In the case where the time (HH:MM) of the home time is 11:02 or 23:02 ("Yes" in STEP S904), in STEP S908, the control unit performs the time correction process. In the case where the time (HH:MM) of the home time is not 11:02 or 23:02 ("No" in STEP S904), the control unit 210 returns to STEP S901, and stands by until a minute carry occurs.

In the case where the number "n" of times of automatic time correction is 3 ("n=3" in STEP S902), in STEP S905, the control unit 210 determines whether the time (HH:MM) of the home time stored in the HT date/time memory 223 is one of 00:02, 08:02, and 16:02. In the case where the time (HH:MM) of the home time is one of 00:02, 08:02, and 16:02 ("Yes" in STEP S905), in STEP S908, the control unit performs the time correction process. In the case where the time (HH:MM) of the home time is not one of 00:02, 08:02, and 16:02 ("No" in STEP S**905**), the control unit **210** returns to STEP S**901**, and stands by until a minute carry occurs.

As described above, after the time difference stored in the HT time difference memory **221** is changed, as time goes on, the control unit **210** decreases the frequency at which the time correction process should be performed. Therefore, for a user who does not frequently change the time difference, in other words, for a user who does not frequently moves from a time zone to another time zone, the electronic timepiece **1** sets a low frequency at which the time correction process should be performed. Therefore, it is possible to further suppress the power consumption of the electronic timepiece **1**.

Fifth Embodiment

The electronic timepiece **1** according to any one of the first embodiment to the fourth embodiment may be configured to detect the voltage of a battery configured to supply power to the electronic timepiece **1** and decrease the frequency at which the time correction process should be performed as the detected voltage decreases. Hereinafter, the functional configuration of an electronic timepiece **1** according to a fifth embodiment will be described. As shown in FIG. **14**, in the electronic timepiece **1**, the control unit **210** functions as a frequency changing unit **213***b*, instead of the frequency changing unit **213** of the first embodiment. Also, the control unit **210** further functions as a battery voltage detecting unit **214**.

The control unit **210** which functions as the battery voltage detecting unit **214** detects the voltage (battery voltage) of a battery (not shown in the drawings) configured to supply power to the electronic timepiece **1**. As the battery voltage detected by the battery voltage detecting unit **214** decreases, the frequency changing unit **213***b* decreases the frequency at which the time correction process should be performed. In the present embodiment, in the case where the detected battery voltage is lower than a threshold V**1** (the case where the battery voltage is a second low level), the frequency changing unit **213***b* does not perform the time correction process, in other words, the frequency changing unit sets the frequency at which the time correction process should be performed to zero times per day. Meanwhile, in the case where the detected battery voltage is equal to or higher than the threshold V**1** and is lower than a threshold V**2** (V**1**<V**2**) (the case where the battery voltage is at a first low level), the frequency changing unit **213***b* sets the frequency at which the time correction process should be performed to once per day. Also, in the case where the detected battery voltage is equal to or higher than the threshold V**2** (the case where the battery voltage is at a middle level or a high level), the frequency changing unit **213***b* sets the frequency at which the time correction process should be performed to 4 times per day.

Now, a battery voltage detecting process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **15**. The control unit **210** performs the battery voltage detecting process, for example, if the power of the electronic timepiece **1** is turned on.

First, in STEP S**1001**, the control unit **210** detects the voltage of the battery of the electronic timepiece. Subsequently, in STEP S**1002**, the control unit **210** determines whether the detected battery voltage is lower than the threshold V**1**. In the case where the detected battery voltage is lower than the threshold V**1** ("Yes" in STEP S**1002**), in STEP S**1003**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 0. Then, the control unit **210** returns to STEP S**1001**.

In the case where the detected battery voltage is equal to or higher than the threshold V**1** ("No" in STEP S**1002**), in STEP S**1004**, the control unit **210** determines whether the detected battery voltage is lower than the threshold V**2**. In the case where the detected battery voltage is lower than the threshold V**2** ("Yes" in STEP S**1004**), in STEP S**1005**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 1. Then, the control unit **210** returns to STEP S**1001**.

In the case where the detected battery voltage is equal to or higher than the threshold V**2** ("No" in STEP S**1004**), in STEP S**1006**, the control unit **210** determines whether the value of the automatic time correction counter **229** is 0. In the case where the value of the automatic time correction counter **229** is 0 ("Yes" in STEP S**1006**), in STEP S**1007**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4. Then, the control unit **210** returns to STEP S**1001**. Meanwhile, in the case where the value of the automatic time correction counter **229** is not 0 ("No" in STEP S**1006**), the control unit **210** returns to STEP S**1001**.

Now, the automatic time correction process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **16**. The control unit **210** performs processes identical to STEPS S**401** to S**405** of the automatic time correction process shown in FIG. **6** in STEPS S**1101**, S**1102**, and S**1104** to S**1106**, and further performs the following process of STEP **1103**.

In the case where the number "n" of times of automatic time correction is 0 ("n=0" in STEP S**1102**), the control unit **210** returns to STEP S**1101**.

In the case where the number "n" of times of automatic time correction is 1 ("n=1" in STEP S**1102**), in STEP S**1103**, the control unit **210** determines whether the time (HH:MM) of the home time stored in the HT date/time memory **223** is 17:02. In the case where the time (HH:MM) of the home time is 17:02 ("Yes" in STEP S**1103**), in STEP S**1106**, the control unit performs the time correction process. In the case where the time (HH:MM) of the home time is not 17:02 ("No" in STEP S**1103**), the control unit **210** returns to STEP S**1101**.

As described above, as the detected battery voltage of the electronic timepiece **1** decreases, the control unit **210** decreases the frequency at which the time correction process should be performed. Therefore, in the case where the battery voltage of the electronic timepiece **1** is low, it is possible to further suppress the power consumption of the electronic timepiece **1**.

Sixth Embodiment

The electronic timepiece **1** according to any one of the first embodiment to the fifth embodiment may be configured to decrease the frequency at which the time correction process should be performed as the duration of a sleep state in which a predetermined operation is not performed is long and lengthens and perform the time correction process if the electronic timepiece is released from the sleep state. Hereinafter, the functional configuration of an electronic timepiece **1** according to a sixth embodiment will be described. As shown in FIG. **17**, in the electronic timepiece **1**, the control unit **210** functions as a frequency changing unit

213*c*, instead of the frequency changing unit **213** of the first embodiment. Also, the control unit **210** further functions as a sleep control unit **215**.

The control unit **210** which functions as the sleep control unit **215** controls the sleep state in which the predetermined operation is not performed. In the present embodiment, the electronic timepiece **1** includes, for example, a brightness sensor (not shown in the drawings) configured to detect the ambient brightness of the electronic timepiece **1**, and the control unit **210** determines whether the brightness detected by the brightness sensor is equal to or larger than a predetermined value, or not, in other words, whether the electronic timepiece **1** is being used. If a state where the brightness detected by the brightness sensor is smaller than the predetermined value, i.e. a state where the electronic timepiece **1** is not being used continues for a predetermined time (for example, 1 hour), the control unit **210** switches the electronic timepiece to the sleep state in which the second hand is not operated. Further, if the sleep state continues for a predetermined period (for example, 1 week), the control unit **210** switches the electronic timepiece to a complete sleep state in which all hands are not operated. Furthermore, in the sleep state or the complete sleep state, if the brightness detected by the brightness sensor is equal to or larger than the predetermined value, in other words, if it is determined that the electronic timepiece **1** is being used, the control unit **210** releases the sleep state or the complete sleep state, and operates all hands.

The control unit **210** which functions as the frequency changing unit **213***c* decreases the frequency at which the time correction process should be performed as the period of the sleep state is long, and performs the time correction process if the electronic timepiece is released from the sleep state. In the present embodiment, if the electronic timepiece transitions to the sleep state, the control unit **210** sets the frequency at which the time correction process should be performed to once per day, and if the electronic timepiece transitions to the complete sleep state, the control unit sets the frequency at which the time correction process should be performed to zero times per day. Also, if the sleep state or the complete sleep state is released, the control unit **210** performs the time correction process, and sets the frequency at which the time correction process should be performed thereafter, to 4 times per day.

Now, a sleep control process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **18**. The control unit **210** performs the sleep control process, for example, if the power of the electronic timepiece **1** is turned on.

First, in STEP S**1201**, the control unit **210** determines whether the detected ambient brightness of the electronic timepiece **1** is smaller than the predetermined value. In the case where the detected brightness is smaller than the predetermined value ("Yes" in STEP S**1201**), in STEP S**1202**, the control unit determines whether the detected brightness has been smaller than the predetermined value for 1 hour or more. Meanwhile, in the case where the brightness is equal to or larger than the predetermined value ("No" in STEP S**1201**), or in the case where the detected brightness has not been smaller than the predetermined value for 1 hour or more ("No" in STEP S**1202**), the control unit **210** returns to STEP S**1201**.

In the case where the detected brightness has been smaller than the predetermined value for 1 hour or more ("Yes" in STEP S**1202**), in STEP S**1203**, the control unit **210** switches the electronic timepiece to the sleep state. Subsequently, in STEP S**1204**, the control unit **210** sets 0 in the automatic time correction counter **229**. Also, in STEP S**1205**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 1.

Subsequently, in STEP S**1206**, the control unit **210** determines whether the detected ambient brightness of the electronic timepiece **1** is smaller than the predetermined value. In the case where the detected brightness is equal to or larger than the predetermined value ("No" in STEP S**1206**), the control unit **210** proceeds to STEP S**1211**. In the case where the detected brightness is smaller than the predetermined value ("Yes" in STEP S**1206**), in STEP S**1207**, the control unit determines whether the detected brightness has been smaller than the predetermined value for 1 week or more. In the case where the detected brightness has not been smaller than the predetermined value for 1 week or more ("No" in STEP S**1207**), the control unit **210** returns to STEP S**1206**.

In the case where the detected brightness has been smaller than the predetermined value for 1 week or more ("Yes" in STEP S**1207**), in STEP S**1208**, the control unit **210** switches the electronic timepiece to the complete sleep state. Then, in STEP S**1209**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230**, with 0.

Subsequently, in STEP S**1210**, the control unit **210** determines whether the detected ambient brightness of the electronic timepiece **1** is smaller than the predetermined value. In the case where the detected brightness is equal to or larger than the predetermined value ("No" in STEP S**1210**), the control unit **210** proceeds to STEP S**1211**. In the case where the detected brightness is smaller than the predetermined value ("Yes" in STEP S**1210**), the control unit **210** stands by.

Then, the control unit **210** releases the sleep state or the complete sleep state in STEP S**1211**, and performs the time correction process in STEP S**1212**. Subsequently, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4 in STEP S**1213**, and returns to STEP S**1201**.

According to the number of times of automatic time correction set by the above-described process, the control unit **210** can perform the automatic time correction process shown in FIG. **16**, similarly in the fifth embodiment.

As described above, as the period of the sleep state in which the predetermined operation is not performed is long, the control unit **210** of the electronic timepiece **1** according to the present embodiment decreases the frequency at which the time correction process should be performed. Therefore, while the electronic timepiece **1** is not used, the control unit sets a low frequency at which the time correction process should be performed. Therefore, it is possible to further suppress the power consumption of the electronic timepiece **1**.

Seventh Embodiment

The electronic timepiece **1** according to any one of the first embodiment to the sixth embodiment may be configured to decrease the frequency at which the time correction process should be performed as the period the time correction process has failed is long and lengthens. Hereinafter, the functional configuration of an electronic timepiece **1** according to a seventh embodiment will be described. As shown in FIG. **19**, in the electronic timepiece **1**, the control unit **210** functions as a frequency changing unit **213***d*, instead of the frequency changing unit **213** of the first embodiment.

The control unit **210** which functions as the frequency changing unit **213***d* changes the frequency at which the time correction process should be performed, according to the period when the time correction process has failed. For example, in the time correction process, if the external device is separated from the electronic timepiece **1** or the external device is not scanned, the electronic timepiece fails in connection with the external device. In this case, the control unit **210** determines that the time connection process has failed. Also, as the period when the time correction process has failed is long and lengthens, the control unit **210** decreases the frequency at which the time correction process should be performed.

A frequency changing process of the electronic timepiece **1** according to the present embodiment will be described with reference to FIG. **20**. If a week carry (start of Sunday of a new week at 1 second from 23:59:59 on Saturday of each week) occurs, the control unit **210** performs the frequency changing process.

First, in STEP S**1301**, the control unit **210** determines whether a week carry (start of a new week) has occurred. In the case where a week carry has not occurred ("No" in STEP S**1301**), the control unit **210** stands by. In the case where a week carry has occurred ("Yes" in STEP S**1301**), in STEP S**1302**, the control unit **210** determines whether the value of the automatic time correction counter **229** is 0. In the case where the value of the automatic time correction counter **229** is not 0 ("No" in STEP S**1302**), the control unit **210** returns to STEP S**1301**.

In the case where the value of the automatic time correction counter **229** is 0 ("Yes" in STEP S**1302**), in STEP S**1303**, the control unit **210** determines whether the time correction process has failed for 3 weeks or more. In the case where the time correction process has failed for 3 weeks or more ("Yes" in STEP S**1303**), in STEP S**1304**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 1. Then, the control unit **210** returns to STEP S**1301**.

In the case where the time correction process has not failed for 3 weeks or more ("No" in STEP S**1303**), in STEP S**1305**, the control unit **210** determines whether the time correction process has failed for 2 weeks or more. In the case where the time correction process has failed for 2 weeks or more ("Yes" in STEP S**1305**), in STEP S**1306**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 2. Then, the control unit **210** returns to STEP S**1301**.

In the case where the time correction process has not failed for 2 weeks or more ("No" in STEP S**1305**), in STEP S**1307**, the control unit **210** determines whether the time correction process has failed for 1 week or more. In the case where the time correction process has failed for 1 week or more ("Yes" in STEP S**1307**), in STEP S**1308**, the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 3. Then, the control unit **210** returns to STEP S**1301**.

In the case where the time correction process has not failed for 1 week or more ("No" in STEP S**1307**), the control unit **210** updates the number of times of automatic time correction stored in the automatic time correction frequency memory **230** with 4 in STEP S**1309**, and returns to STEP S**1301**.

By the above-described process, the control unit **210** decreases the number of times of automatic time correction by 1 whenever the period when the time correction process has failed is long and lengthens by 1 week. Also, if the period when the time correction process has failed becomes 3 weeks or more, the control unit **210** sets the frequency at which the time correction process should be performed to once per day.

According to the number of times of automatic time correction set by the above-described process, the control unit **210** can perform the automatic time correction process shown in FIG. **13**, similarly in the fourth embodiment.

As described above, the control unit **210** of the electronic timepiece **1** according to the present embodiment decreases the frequency at which the time correction process should be performed as the period when the time correction process has failed is long and lengthens. Therefore, while the electronic timepiece **1** cannot access the external device, the control unit sets a low frequency at which the time correction process should be performed. Therefore, it is possible to further suppress the power consumption of the electronic timepiece **1**.

However, the present invention is not limited to the above-described embodiments, and can be modified in various forms.

For example, in the first embodiment to the seventh embodiment described above, the example in which the electronic timepiece **1** receives the external time by wireless communication based on BLE with the external device. However, the communication method between the electronic timepiece **1** and the external device is not limited thereto. For example, the electronic timepiece **1** may receive a standard long wave or a GPS wave from a standard-long-wave transmitting station or a GPS (Global Positioning System) satellite which is an external device, and correct the time clocked by the counter **241**, on the basis of the wave received from the transmitting station or the GPS satellite.

Hereinafter, a modification in which the electronic timepiece **1** according to the first embodiment corrects the time by receiving a standard long wave or a GPS wave instead of wireless communication based on BLE with the external device will be described. FIG. **21** is a flow chart of a time correction process which the control unit **210** of the electronic timepiece **1** according to the present modification performs instead of the time correction process of the first embodiment shown in FIG. **7**.

First, in STEP S**1401**, the control unit **210** receives a standard long wave or a GPS wave via the communication unit **244**. In the case of receiving a standard long wave, a standard-long-wave transmitting station may be selected on the basis of the time difference of the home time (the city code).

Subsequently, in STEP S**1402**, the control unit **210** generates the date and time and 1/256-second information of the reception area on the basis of the received standard long wave or the received GPS wave.

Next, in STEP S**1403**, the control unit **210** determines whether the value of the automatic time correction counter **229** is 0. In the case where the value of the automatic time correction counter **229** is not 0 ("No" in STEP S**1403**), in STEP S**1404**, the control unit determines whether the absolute value of the difference between the date and time of the home time stored in the HT date/time memory **223** and the generated date and time is 7.5 minutes or less, or not. In the case where the absolute value is not 7.5 minutes or less ("No" in STEP S**1404**), the control unit **210** returns to STEP S**401** of the automatic time correction process shown in FIG. **6**.

In the case where the value of the automatic time correction counter **229** is 0 ("Yes" in STEP S**1403**), or in the case where the absolute value of the difference between the date and time of the home time stored in the HT date/time memory **223** and the generated date and time is 7.5 minutes or less ("Yes" in STEP S**1404**), in STEP S**1405**, the control unit **210** updates the 1/256-second memory **227** with the generated 1/256-second information, and updates the HT date/time memory **223** with the generated date and time. However, unlike the first embodiment, in the present modification, the daylight saving time information and the time difference are not corrected.

Subsequently, in STEP S**1406**, the control unit **210** calculates Coordinated Universal Time (UTC) by subtracting the time difference stored in the HT time difference memory **221** and the daylight saving time information stored in the HT_DST memory **222** from the date and time of the home time stored in the HT date/time memory **223**, and obtains the date and time of the dual time by adding the time difference stored in the DT time difference memory **224** and the daylight saving time information stored in the DT_DST memory **225** to the Coordinated Universal Time (UTC), and stores the obtained date and time in the DT date/time memory **226**. Then, the control unit **210** returns to STEP S**401** of the automatic time correction process shown in FIG. **6**.

By the above-described process, the electronic timepiece **1** according to the present modification can correct the time clocked by the counter **241**, on the basis of the standard long wave or the GPS wave. Also, similarly in the first embodiment, if the operation member **243** receives a time correction operation, the electronic timepiece **1** according to the present modification sets a frequency at which the time correction process should be performed, higher than that before the reception of the time correction operation, until the predetermined time elapses. Therefore, after the user manually corrects the time of the electronic timepiece **1**, even if the user moves to another time zone, it is possible to quickly correct the time. Also, if the predetermined time elapses after reception of a time correction operation, the control unit **210** of the electronic timepiece **1** sets the original frequency again. Therefore, it is possible to suppress power consumption from increasing due to the time correction process.

Also, although the above-described flow chart is a flow chart which is used in the case where the electronic timepiece **1** according to the first embodiment corrects the time by receiving a standard long wave or a GPS wave, instead of wireless communication based on BLE with the external device, it can also be applied to the electronic timepieces **1** according to the second embodiment to the seventh embodiment.

Also, in the above description, the ROM **102** configured with a non-volatile memory such as a flash memory has been described as an example of a computer-readable medium for storing the programs related to various processes of the present invention. However, the computer-readable medium is not limited thereto, and portable recording media such as a hard disk drive (HDD), a compact disc read only memory (CD-ROM), and a digital versatile disc (DVD) can be applied. Also, as a medium for providing data on the programs according to the present invention, carrier waves also can be applied to the present invention.

Moreover, the details such as the specific components, the control procedures, and the display examples shown in the above-described embodiments can be appropriately modified without departing from the scope of the present invention.

Although some embodiments of the present invention have been described, the scope of the present invention is not limited to the above described embodiments, and includes the scopes of inventions disclosed in claims and the scopes of their equivalents.

What is claimed is:

1. A communication device comprising:

a receiver that receives, from an external device, (i) an external time and (ii) a time difference between the external time and Coordinated Universal Time;

a counter that clocks time;

an operation member that receives a time correction operation from a user to correct the time clocked by the counter; and

a processor that controls the receiver to receive the external time, and that controls to perform a time correction process to correct the time clocked by the counter to the received external time,

wherein the processor performs processes comprising:

setting a frequency at which the time correction process is performed after the operation member receives the time correction operation to be higher than a frequency at which the time correction process is performed before the operation member receives the time correction operation, until a predetermined time elapses; and

in the time correction process, correcting the time clocked by the counter to the received external time when the difference between the time clocked by the counter and the received external time is within a predetermined range, and

wherein after the time difference received by the receiver changes, as time goes on, the processor decreases the frequency at which the time correction process is performed.

2. The communication device according to claim **1**, wherein:

the operation member receives, as the time correction operation, an operation to correct the time clocked by the counter to a time designated by the user.

3. The communication device according to claim **1**, wherein:

the operation member receives, as the time correction operation, an operation to correct the time clocked by the counter to the received external time.

4. The communication device according to claim **1**, wherein:

the processor detects a voltage of a battery which supplies power to the communication device, and decreases the frequency at which the time correction process is performed as the detected voltage decreases.

5. The communication device according to claim **1**, wherein:

the communication device does not perform a predetermined operation in a sleep state, and

as a period of the sleep state increases, the processor decreases the frequency at which the time correction process is performed.

6. The communication device according to claim **1**, wherein:

as a period in which the time correction process has failed increases, the processor decreases the frequency at which the time correction process is performed.

7. An electronic timepiece comprising:
the communication device according to claim **1**; and
a display that displays the time clocked by the counter.

8. A communication method comprising:
controlling a receiver to receive, from an external device, (i) an external time and (ii) a time difference between the external time and Coordinated Universal Time;
performing a time correction process to correct time clocked by a counter to the received external time;
setting a frequency at which the time correction process is performed after an operation member receives an operation from a user to correct the time clocked by the counter to be higher than a frequency at which the time correction process is performed before the operation member receives the operation, until a predetermined time elapses; and
in the time correction process, correcting the time clocked by the counter to the received external time when the difference between the time clocked by the counter and the received external time is within a predetermined range.

9. A non-transitory computer-readable recording medium storing a program readable by a computer including a receiver which receives, from an external device, (i) an external time and (ii) a time difference between the external time and Coordinated Universal Time, a counter which clocks time, and an operation member which receives a time correction operation of a user to correct the time clocked by the counter, the program being executable to cause the computer to perform operations comprising:
controlling the receiver to receive the external time;
performing a time correction process to correct the time clocked by the counter to the received external time;
setting a frequency at which the time correction process is performed after the operation member receives the time correction operation to be higher than a frequency at which the time correction process is performed before the operation member receives the time correction operation, until a predetermined time elapses; and
in the time correction process, correcting the time clocked by the counter to the received external time when the difference between the time clocked by the counter and the received external time is within a predetermined range.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,996,636 B2
APPLICATION NO. : 15/900445
DATED : May 4, 2021
INVENTOR(S) : Morohoshi

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 23, Line 21 (Claim 8), delete "range." and insert --range wherein after the time difference received by the receiver changes, as time goes on, the frequency at which the time correction process is performed is decreased.--.

Column 24, Line 21 (Claim 9), delete "range." and insert --range wherein after the time difference received by the receiver changes, as time goes on, the frequency at which the time correction process is performed is decreased.--.

Signed and Sealed this
First Day of March, 2022

Drew Hirshfeld
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office